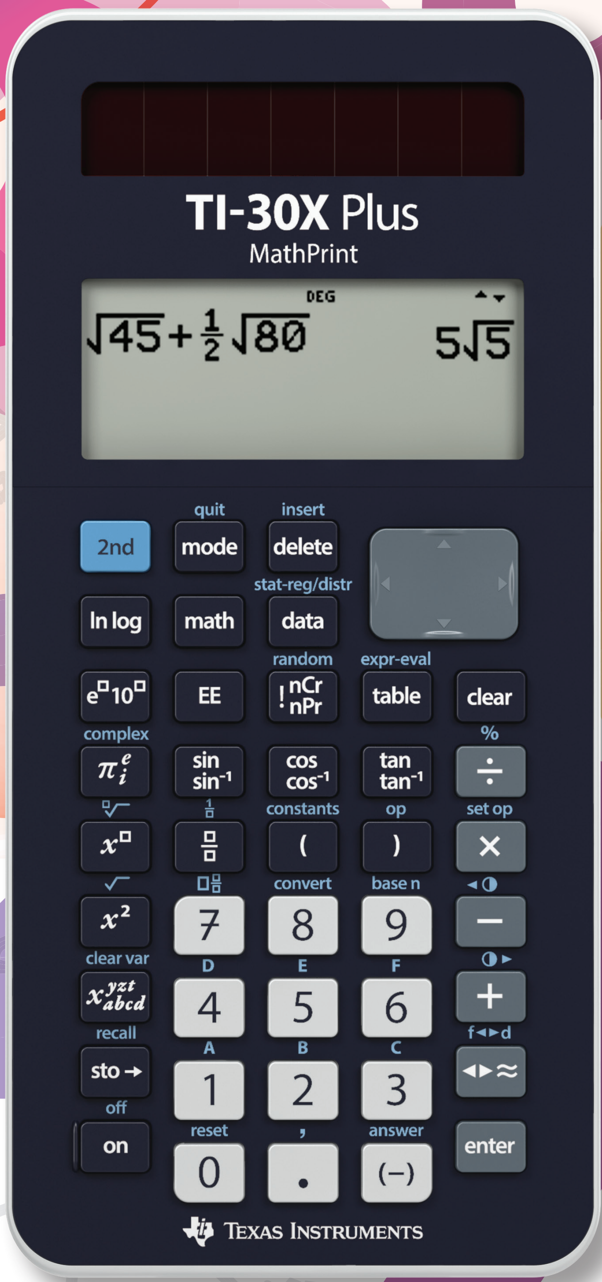
TI-30X Plus MathPrint™

Scientific Calculator

Guidebook for HSC Mathematics Advanced
Part 1



Texas Instruments

TI-30X Plus MathPrint™ Scientific Calculator Guidebook
NSW Stage 6 Mathematics Advanced

Table of Contents

About this guidebook

This guidebook is designed to show ways in which the TI-30X Plus MathPrint™ scientific calculator can augment and enhance the teaching and learning of NSW Stage 6 Mathematics Advanced.

The first chapter of the guidebook is a getting started chapter which provides an overview of features such as display settings, modes and menus. In addition, the getting started chapter gives some general guidance for navigating around the calculator, on calculator syntax and tips for efficient and accurate calculation.

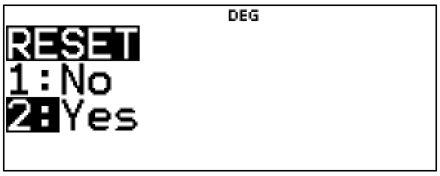
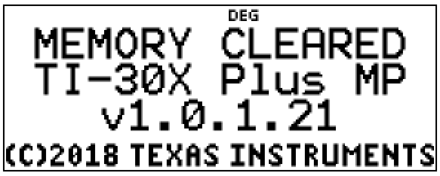
Throughout the chapters on Functions, Trigonometric Functions, Calculus, Exponential and Logarithmic Functions, Financial Mathematics and Statistical Analysis, calculator features and menus relevant to the subject matter are introduced and explained. In terms of features (math tools), for example, the conversions feature is introduced on page 16, the function feature is introduced on page 29, the data editor and list formulas feature is introduced on page 35, the stored operation feature is introduced on page 36 and the expression evaluation feature is introduced on page 39. In terms of menus, for example, the statistics – regressions (**STAT - REG**) menu is introduced at the start of the section on Statistical Analysis (page 121).

The examples showcased in this guidebook are relevant to NSW Stage 6 Mathematics Advanced. Most examples include a brief teaching note. Such teaching notes can provide a mathematical purpose for the example, highlight the mathematical concepts being developed in the example and describe how that example might fit in with the aims and outcomes of using calculators judiciously in Mathematics teaching and learning.

The examples generally follow a two-column table format. In most examples, the left-hand column displays step-by-step keystrokes that demonstrate TI-30X Plus MathPrint functionality accompanied by a solution outline and notes. Where applicable, the right-hand column displays accompanying screenshots.

All examples in this guidebook assume the default settings as shown in Section 0.5 (page 7) on modes. If desired, the TI-30X Plus MathPrint can be reset so that all students start at the same point.

Calculator Reset:

Press [2nd] [reset] [2]		

0 Getting started

This chapter provides an overview of features such as display settings, modes and menus.

It also gives some general guidance on navigation around the calculator, on calculator syntax and tips for efficient and accurate calculation.

0.1 Switching the calculator on and off

Press: [on] to turn the TI-30X Plus MathPrint on.

Press: [2nd] [off] to turn it off.

While the display is cleared, the history settings and memory are retained.

If no key is pressed for approximately 3 minutes, the APD™ (Automatic Power Down™) feature turns off the TI-30X Plus MathPrint automatically.

Press [on] after APD™ and the display, pending operations, settings and memory are retained.

0.2 Display contrast

To adjust the contrast:

(1) Press and release the [2nd] key.

(2) Press: [◑▸] to darken the screen or press [◂◑] to lighten the screen.

Note: This adjusts the contrast one level at a time. Repeat the above steps as needed.

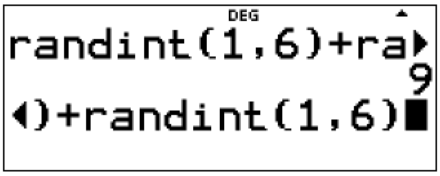
0.3 Home screen

The TI-30X Plus MathPrint can display a maximum of 4 lines with a maximum of 16 characters per line.

Keystrokes description:

For entries and expressions longer than the visible screen area, scroll left and right (◀ and ▶) to view the entire entry or expression.

Depending on space, the answer is displayed either directly to the right of the entry or on the right side of the next line.



In MathPrint mode, you can enter up to four levels of consecutive nested functions and expressions, which include fractions, square roots, exponents with ^, $\sqrt[x]{y}$, e^x and 10^x.

Special indicators and cursors may display on the screen to provide additional information concerning functions or results.

Indicator	Definition
2ND	2nd function.
FIX	Fixed-decimal setting.
SCI, **ENG**	Scientific or engineering notation.
DEG, **RAD**, **GRAD**	Angle mode (degrees, radians or gradians).
L1, **L2**, **L3**	Displays above the lists in data editor.
H, **B**, **O**	Indicates **HEX**, **BIN** or **OCT** number-base mode. No indicator is displayed for default **DEC** mode.
⧗	The calculator is performing an operation. Press [on] to break the calculation.
▲ ▼	An entry is stored in memory before and/or after the visible screen area. Press (▲) and (▼) to scroll.
▶	Indicates that the multi-tap key is active.
■	Normal cursor. Shows where the next item you type will appear. Replaces any current character.
▒	Entry-limit cursor. No additional characters can be entered.
▬	Insert cursor. A character is inserted in front of the cursor location.
⬚	Placeholder box for empty MathPrint template. Use arrow keys to move into the box.
◨	MathPrint cursor. Continue entering in the current MathPrint template or press (▶) to exit the template.

0.4 2nd functions

Press: [2nd] to activate the secondary function of a given key. Note that **2ND** appears as an indicator on the screen. To cancel before pressing the next key, press: [2nd] again.

Example: Activating a 2nd function

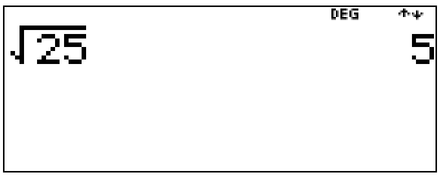
Press: [2nd] [√] to calculate the square root of a non-negative value.

Use the TI-30X Plus MathPrint to calculate $\sqrt{25}$.

Keystrokes and solution:

Press: [2nd] [√] and enter **25** [enter]

$\sqrt{25} = 5$



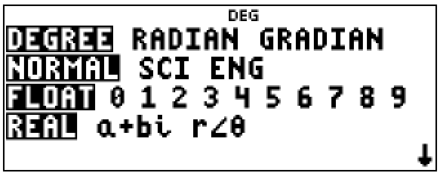
0.5 Modes

Press: [mode] to choose modes.

Press: ▼ ▲ ◄ ► to choose a mode and press: [enter] to select it.

Press: [clear] or [2nd] [quit] to return to the home screen and perform your calculations using the chosen mode settings.

Default mode settings are highlighted in the following two screenshots.



DEGREE RADIAN GRADIAN sets the angle mode.

NORMAL SCI ENG sets the numeric notation mode.

- **NORMAL** displays results with digits to the left and right of the decimal point.
  Example: 123456.78.
- **SCI** expresses numbers with one digit to the left of the decimal point and the appropriate power of 10.
  Example: 1.2345678E5 is equivalent to 1.2345678×10^5.
- **ENG** displays results as a number from 1 – 999 times 10 to an integer power. The integer power is always a multiple of 3.
  Example: 123.45678 E3 .
  Note: [EE] is a shortcut key to enter a number in scientific notation format.

FLOAT 0123456789 sets the decimal notation mode.

- **FLOAT** (floating decimal point) displays up to 10 digits, plus the sign and decimal point.
- **0123456789** (fixed decimal point) specifies the number of digits (0 through 9) to display to the right of the decimal point.

REAL a+bi r∠θ sets the format of complex number results.

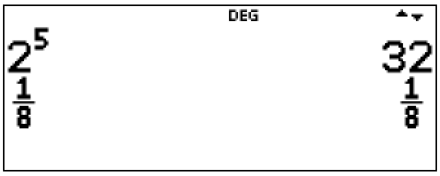
- **REAL** real results.
- **a+bi** rectangular results.
- **r∠θ** polar results.

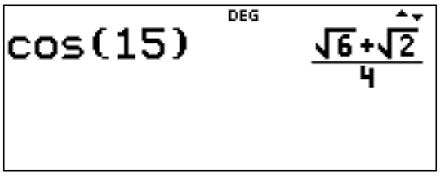
DEC HEX BIN OCT sets the number base.

- **DEC** decimal (base 10).
- **HEX** hexadecimal (base 16). To enter hex digits **A** through **F**, use [2nd] [A] etc.
- **BIN** binary (base 2).
- **OCT** octal (base 8).

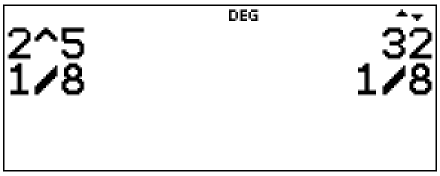
MATHPRINT CLASSIC

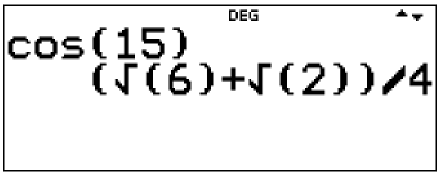
- **MATHPRINT** mode displays most inputs and outputs in textbook format.





- **CLASSIC** mode displays inputs and outputs in a single line.





0.6 Multi-tap keys

When pressed, a multi-tap key cycles through multiple functions.

Press: [▶] to break multi-tap cycle.

For example, press [sin $\sin^{-1}$] to access **sin**, **$\sin^{-1}$**, **sinh** and **$\sinh^{-1}$**.

Press the key repeatedly to display the function you wish to enter.

Multi-tap keys include [$x\ {}^{yzt}_{abcd}$], [sin $\sin^{-1}$], [cos $\cos^{-1}$], [tan $\tan^{-1}$], [$e^{\square}$ $10^{\square}$], [ln log], [! nCr nPr] and [π e i].

0.7 Menus

Menus provide access to a number of calculator functions.

Some menu keys, such as [2nd] [recall], display a single menu.

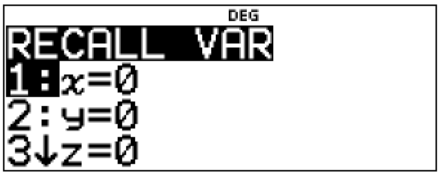
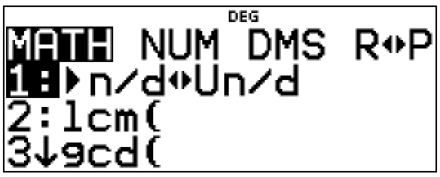
Others, such as [math], display multiple menus.

Press: [▶] and [▼] to scroll and select a menu item or press the corresponding number next to the item.

To return to the previous screen without selecting the item, press [clear].

To exit a menu and return to the home screen, press [2nd] [quit].

Keystrokes description:

One-Dimensional Menu Press: [2nd] [recall] (key with single menu) to access **RECALL VAR**.	
Two-Dimensional Menu Press [math] (key with multiple menus) to access **MATH**, **NUM**, **DMS** and **R◀▶ P**.	

0.8 Scrolling expressions and history

Press ◀ or ▶ to move the cursor within an expression that you are entering or editing.

Press [2nd] ◀ to move the cursor directly to the beginning of the expression.

Press [2nd] ▶ to move the cursor directly to the end of the expression.

From an expression or edit, press ▲ or ▼ to move the cursor through previous entries in the history. Pressing [enter] from an input or output in history will paste that expression back to the cursor position on the edit line.

Press [2nd] ▲ from the denominator of a fraction in the expressions edit to move the cursor to the history. Pressing [enter] from an input or output in the history will paste that expression to the denominator.

Example: Scrolling expressions and history

Press [x^2] to calculate the square of a value.

Use the TI-30X Plus MathPrint to calculate

(a) $17^2 - 7^2$.

(b) $\sqrt{17^2 - 7^2}$, giving your answer in exact form.

Teacher Note: Students need sound mental computation strategies to determine the value of $17^2 - 7^2$ or sound estimation strategies to obtain a good estimate of its value.

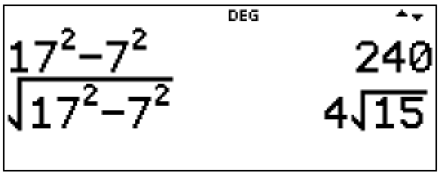
Keystrokes and solution:

(a) Enter **17** and press: [x^2] [−]. Enter **7** and press: [x^2] [enter]

$17^2 - 7^2 = 240$

(b) Press: [2nd] [√] ▲ ▲ [enter] [enter]

$\sqrt{17^2 - 7^2} = 4\sqrt{15}$



0.9 Answer toggle

Press [◄►≈] to toggle the display result (when possible) between fraction and decimal answers, surd and decimal answers and multiples of π and decimal answers.

Example: Using answer toggle

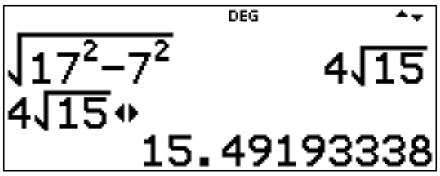
Use the TI-30X Plus MathPrint to express $4\sqrt{15}$ in decimal form.

Keystrokes and solution:

Enter $4\sqrt{15}$ or use the last output from the previous example by pressing ▲ [enter].

Press [◄►≈] to toggle between exact form and decimal form, then press: [enter]

$4\sqrt{15} = 15.49...$



Note: [◄►≈] is available to toggle number formats for values in cells in the Function table and in the Data Editor.

0.10 Last answer

Press: [2nd] [answer].

The last entry performed on the home screen is stored to the variable **ans**. This variable is retained in memory even after the TI-30X Plus MathPrint is turned off.

To recall the value of **ans**, press [2nd] [answer] (**ans** displays on the screen), or press any operation key ([+], [−] etc.) in most edit lines as the first part of an entry. The variable **ans** and the operator are both displayed. The variable **ans** is stored and pastes in full precision which is 13 digits.

Example: Using last answer

The following example shows how the variable **ans** can preserve continuity in calculations.

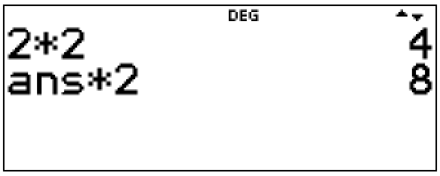
Keystrokes description:

Enter **2** and press [×]. Enter **2** and press [enter].

$2\times 2=4$

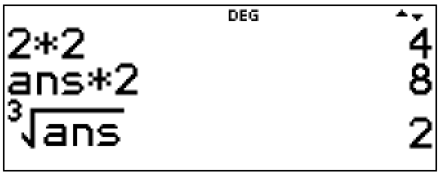
Press [×] and enter **2.** Press [enter].

$2\times 2\times 2=8$



Enter **3** and press [2nd] [$\sqrt[\square]{\ }$] [2nd] [answer] [enter].

$\sqrt[3]{2\times 2\times 2}=2$



0.11 Order of operations

Order of operations hierarchy:

(1st) Expressions inside parentheses.

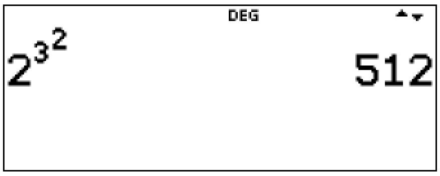
(2nd) Functions that need a closing bracket and precede the argument such as **sin**, **log** and all **R◄► P** menu items.

(3rd) Functions that are entered after the argument, such as $\mathbf{x}^2$ and angle unit modifiers.

(4th) Exponentiation (**^**) and roots.

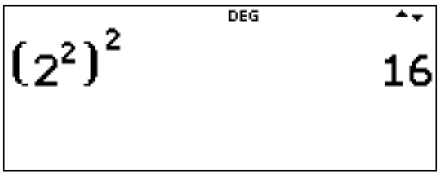
In **MathPrint** mode, exponentiation using the [$x^{\square}$] key is evaluated from right to left.

Example: 2^{3^2} is evaluated as $2^{(3^2)}=512$.

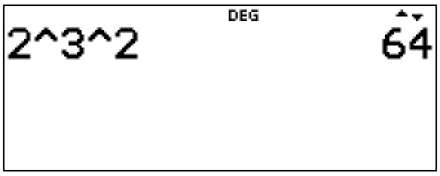


In **Classic** mode, exponentiation using the [$x^{\square}$] key is evaluated from left to right.

Example: $2\wedge 3\wedge 2$ is evaluated as $(2\wedge 3)\wedge 2=64$.



Example: pressing: [2] [x^2] [x^2] [enter] is calculated as $\left(2^2\right)^2=16$.



(5th) Negation [(–)].

(6th) Fractions.

(7th) Permutations (**nPr**) and combinations (**nCr**).

(8th) Multiplication, implied multiplication, division and angle indicator $\angle$.

(9th) Addition and subtraction.

(10th) Logic operators **and**, **nand**.

(11th) Logic operators **or**, **xor**, **xnor**.

(12th) Conversions such as ▶ **n/d◀▶ Un/d**, **F◀▶ D**, ▶ **DMS**.

(13th) [sto→]

(14th) [enter] evaluates the input expression.

Note: End of expression operators and angle conversion ▶ **DMS**, for example, are only valid in the home screen. They are ignored in wizards, function table display and data editor features where the expression result, if valid, will display without a conversion.

Example: Order of operations

Use the TI-30X Plus MathPrint to calculate

(a) $42+3\times-14$. (b) $2+-6+9$. (c) $\sqrt{27+37}$.

(d) $5\times(3+4)$. (e) $5(3+4)$. (f) $\sqrt{8^2+15^2}$.

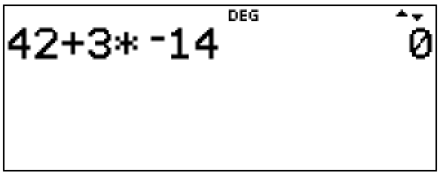
(g) $(-4)^2$ and -4^2.

Keystrokes and solution:

(a) $\times \div + -$

Enter **42** and press: [+] **3** [×] [(–)] **14** [enter].

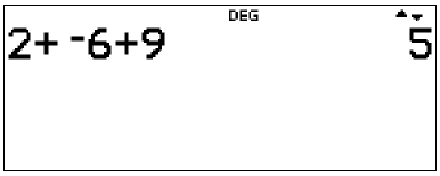
$42+3\times-14=0$



(b) $(-)$

Enter **2** and press: [+] [(–)] **6** [+] **9** [enter].

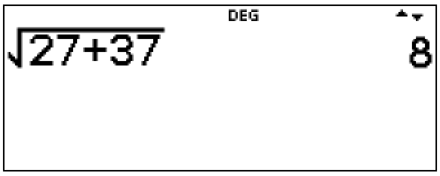
$2+-6+9=5$



(c) $\sqrt{\ }$ and $+$

Press: [2nd] [√] and enter **27** [+] **37** [enter].

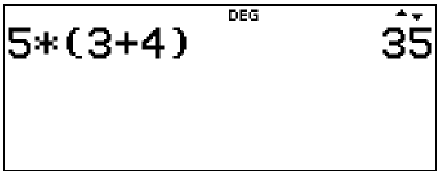
$\sqrt{27+37}=8$



(d) ( )

Enter **5** and press: [×] [(] **3** [+] **4** [)] [enter].

$$5\times(3+4)=35$$



(e) ( ) and +

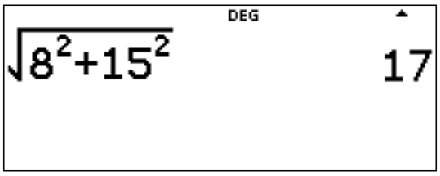
Enter **5** and press: [(] **3** [+] **4** [)] [enter].

$$5(3+4)=35$$

(f) ^ and √

Press: [2nd] [√] and enter **8** [x^2] [+] **15** [x^2] [enter].

$$\sqrt{8^2+15^2}=17$$

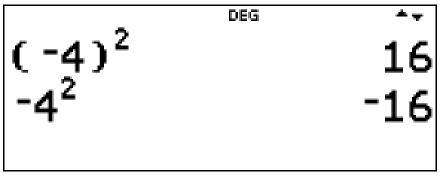


(g) ( ) and –

Press: [(] [(–)] and enter **4** [)] [x^2] [enter].

Press: [(–)] and enter **4** [x^2] [enter].

$$-4^2=-16$$



0.12 Clearing and correcting

Press [2nd] [quit] to return the cursor to the home screen.

Press [clear] to clear an error message. It also clears characters on an author line.

Press [delete] to delete the character at the cursor. When the cursor is at the end of an expression, it will backspace and delete.

Press [2nd] [insert] to insert (rather than replace) a character at the cursor.

Press [2nd] [clear var] [1] to clear variables x, y, z, t, a, b, c, d back to their default values of 0.

Press [2nd] [reset] [2] to return the TI-30X Plus MathPrint to default settings, clears memory variables, pending operations, all entries in history and statistical data; clears any stored operation and **ans**.

0.13 Memory and stored variables

The TI-30X Plus MathPrint has eight memory variables, x, y, z, t, a, b, c and d.

The following can be stored to a memory variable:

- real (or complex) numbers.
- expression results.
- calculations from various menus such as **Distributions**.
- data editor cell values (stored from the edit line).

Features of the TI-30X Plus MathPrint that use variables will use stored values.

Press [sto→] to store a variable and press [x^{yzt}_{abcd}] (a multi-tap key that cycles through the variables x, y, z, t, a, b, c and d) to select the variable to store.

Press [enter] to store the value in the selected variable. If the selected variable already has a stored value, that value is replaced by the new one.

Press [x^{yzt}_{abc}] to recall and use the stored values for these variables. The variable, say y, is inserted into the current entry and the value assigned to y is used to evaluate the expression. To enter two or more variables in succession, press ▶ after each.

Press [2nd] [recall] to display a menu of variables and their stored values. Select the variable you wish to recall and press [enter]. The value assigned to the variable is inserted into the current entry and used to evaluate the expression.

Press [2nd] [clear var] and select **1: Yes** to clear all variable values. Any computed **Stat Vars** will no longer be available in the **Stat Vars** menu and would require recalculation.

Example: Using stored variables

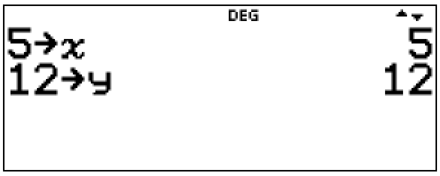
Given that $x = 5$ and $y = 12$, use the TI-30X Plus MathPrint to find the value of $x^2 + y^2$.

Keystrokes and solution:

Press: [2nd] [clear var] [1] to clear variables.

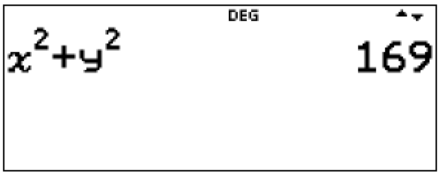
Enter **5** and press [sto→] [x^{yzt}_{abc}] [enter] **12** [sto→] [x^{yzt}_{abcd}] [x^{yzt}_{abcd}] [enter].

Two possible approaches:



Approach 1:

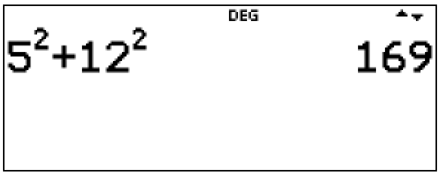
Press: [x^{yzt}_{abcd}] [x^2] [+] [x^{yzt}_{abcd}] [x^{yzt}_{abcd}] [x^2] [enter]



Approach 2:

Press: [2nd] [recall] [1] [x^2] [+] [2nd] [recall] [2] [x^2] [enter]

$x^2 + y^2 = 169$



Note: While this calculation can be performed directly, using memory locations is a powerful way of generalising and maintaining accuracy when the values involved include many digits.

0.14 Unit conversions

The TI-30X Plus MathPrint has a conversions feature that allows a total of 20 conversions (or 40 if converting both ways).

The conversion occurs at the end of an expression and can be stored as a variable.

Press [2nd] [convert] to access the **CONVERSIONS** menu.

The five conversion categories are:

(1) English-Metric.

(2) Temperature.

(3) Speed, length.

(4) Pressure.

(5) Power, Energy.

Example: Performing unit conversions

Use the TI-30X Plus MathPrint conversions feature to convert

(a) 100 degrees Fahrenheit to degrees Celsius, giving your answer correct to one decimal place.

(b) 20 m/s to km/h.

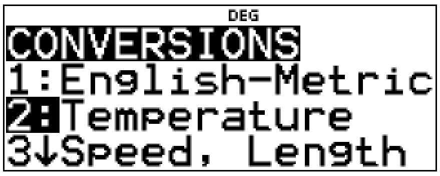
Keystrokes and solution:

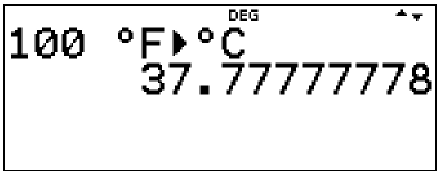
(a) Enter **100** and press: 2nd [convert] 2 to select **Temperature**.

Select **°F► °C** and press: enter enter

100 degrees Fahrenheit converts to 37.8 degrees Celsius (correct to one decimal place).

Note: This conversion can also be made using the formula $C = \frac{5}{9}(F - 32)$.



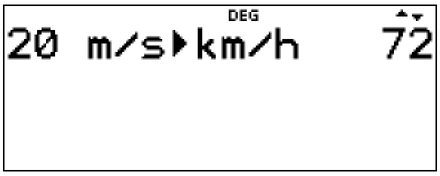


(b) Enter **20** and press 2nd [convert] 3 to select **Speed, Length**.

Press: ⊙ to select **m/s► km/h**. Press enter enter

20 m/s converts to 72 km/h

Note: This conversion can be made by multiplying by 3.6.



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1 Basic mathematical functions

1.1 Fractions

In MathPrint mode, press $\frac{\square}{\square}$.

Fractions with $\frac{\square}{\square}$ can include real (and complex numbers), operation keys (+, × etc.) and most function keys (x^2, 2nd [%], etc.).

Press ⊙ or ⊙ to move the cursor between the numerator and denominator.

Fraction results are automatically simplified, and the output is in improper fraction form.

When a mixed number output is required, press math 1 to access the **► n/d ◄► Un/d** conversion feature.

Press 2nd [$\square\frac{\square}{\square}$] to enter a mixed number. Use the arrow keys to cycle through the unit, numerator and denominator.

Example: Adding fractions

This example shows how to use a calculator to add fractions, including mixed numbers and fractions with different denominators.

Use the TI-30X Plus MathPrint to calculate $\frac{3}{4} + 1\frac{7}{12}$.

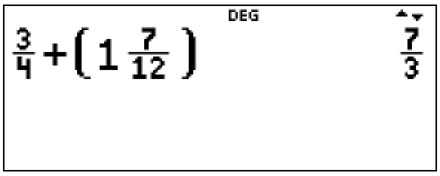
Give your answer as an improper fraction and as a mixed number.

Teacher Note: Students need to be able to convert an improper fraction to a mixed number and vice versa.

Keystrokes and solution:

Enter **3** and press: [n/d] **4** ▶ [+] **1** [2nd] [Un/d] **7** ▼ **12** [enter].

$$\frac{3}{4}+1\frac{7}{12}=\frac{7}{3}$$

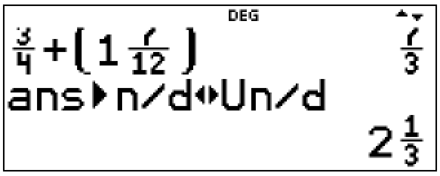


Note: Parentheses are added automatically.

To give the answer as a mixed number:

Press: [math] [1] [enter].

$$\frac{3}{4}+1\frac{7}{12}=2\frac{1}{3}$$



If decimal numbers are used or calculated in a fraction's numerator or denominator, the result will display as a decimal.

Press [2nd] [f◀▶d] when wanting to convert a fraction to a decimal.

Example: Converting a decimal number to an improper fraction

This example shows how to convert a decimal number to an improper fraction.

Use the TI-30X Plus MathPrint to calculate $\frac{1.2+1.3}{4}$.

Give your answer as a decimal number and an improper fraction.

Teacher Note: Students need to be able to convert a decimal number to an improper fraction and vice versa.

Keystrokes and solution:

Press: [n/d] and enter **1.2** [+] **1.3** ▼ **4** [enter]

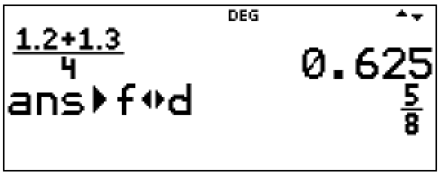
$$\frac{1.2+1.3}{4}=0.625$$

To express the answer as a fraction:

Approach 1: Press [2nd] [f◀▶d] [enter].

Approach 2: Press [math] [1] [enter].

$$0.625=\frac{5}{8}$$



Pressing [n/d] before or after numbers or functions are entered may pre-populate the numerator with parts of your expression. Watch the screen as you press keys to ensure your expression is entered exactly as required.

To paste a previous entry from history in the numerator or mixed number unit, place the cursor in the numerator or unit, press ▲ to scroll to the desired entry and press [enter] to paste the entry to the numerator or unit.

To paste a previous entry from history in the denominator, place the cursor in the denominator, press [2nd] ▲ to jump into history. Press ▲ to scroll to the desired entry and press [enter] to paste the entry to the denominator.

1.2 Percentages

To perform a calculation involving a percentage, press [2nd] [%] after entering the value of the percentage.

Example: Calculating the percentage of a quantity

This example shows how to use a calculator to calculate the percentage of a quantity.

Use the TI-30X Plus MathPrint to calculate 7.5% of 150.

Teacher Note: Students need to be able to estimate the magnitude of the resulting quantity. For example, 10% of 150 is 15.

Keystrokes and solution:

Enter **7.5** and press: [2nd] [%] [×] **150** [enter].

7.5% of 150 is 11.25

1.3 Scientific notation

A number in scientific notation is made up of the following two parts multiplied together.

A number, a, where $1 \leq a < 10$ and a power of 10. Hence numbers of the form a x 10^n where n is an integer.

Press [mode]. **NORMAL SCI ENG** sets the numeric notation mode. In **SCI** mode, numbers are expressed with one digit to the left of the decimal point and the appropriate power of 10.

[EE] is a shortcut key to enter a number in scientific notation format.

Example: Entering numbers in scientific notation format

This example shows how to use a calculator to enter a number in scientific notation format.

Use the TI-30X Plus MathPrint to enter $1.3\text{x}10^{-5}$ as 1.3E-5.

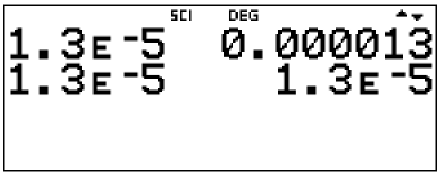
Keystrokes and solution:

Enter **1.3** and press: [EE] [(−)] **5** [enter].

$1.3\text{x}10^{-5} = 0.000013$

To change to **SCI** mode, press [mode] [▼] [▶] [enter].

Press: [clear] [enter].



The [e□ 10□] key is a multi-tap key. Pressing [e□ 10□] [e□ 10□] pastes the base 10 to the power function.

Hence another way of entering a number in scientific notation format, is to Press:[e□ 10□] [e□ 10□]. The result obtained is displayed according to the numeric notation mode setting. Use parentheses to ensure correct order of operation.

Another way of entering a number in scientific notation format, is to enter **10** and press [$x^□$].

Example

This example shows how to use a calculator to find the quotient of two numbers expressed in scientific notation.

Use the TI-30X Plus MathPrint to calculate $\dfrac{5\times 10^{3}}{8\times 10^{-2}}$. Give your answer in scientific notation.

Teacher Note: Students need to be able to estimate the size of a quotient (or a product). This is an important skill when monitoring outputs from calculations performed with technology.

Keystrokes and solution:

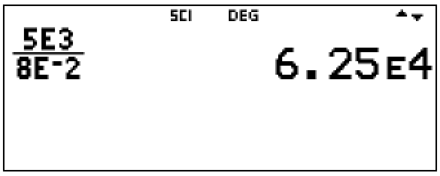
Three approaches are shown.

Press: [mode], select **SCI** and Press: [enter]

Approach 1: Using [EE]

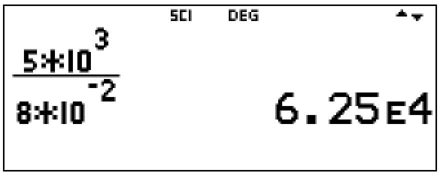
Press: [n/d] and enter **5** [EE] **3** [⏷] **8** [EE] [(−)] **2** [enter]

$$\frac{5\times 10^{3}}{8\times 10^{-2}} = 6.25\times 10^{4}$$



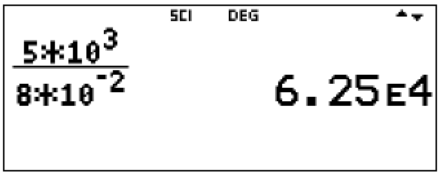
Approach 2: Using [e□10□] Multitap

Press: [n/d] and enter **5** [×] [e□10□] [e□10□] **3** [⏷] **8** [×] [e□10□] [e□10□] [(−)] **2** [enter].



Approach 3: Using [$x^{□}$]

Press: [n/d] and enter **5** [×] **10** [$x^{□}$] **3** [⏷] **8** [×] **10** [$x^{□}$] [(−)] **2** [enter].



1.4 Powers, roots and reciprocals

Press: [x^2] to calculate the square of a value.

Press: [$x^{□}$] to raise a value to the power indicated. Press: [⏵] to move the cursor out of the power in MathPrint mode.

Example: Raising a value to a power

This example shows how to use a calculator to raise a value to the power indicated.

Use the TI-30X Plus MathPrint to calculate

(a) $10^{3}+9^{3}$. (b) $12^{3}+1^{3}$.

Note: The Hardy-Ramanujan Number, 1729, is the smallest number which can be expressed as the sum of two different cubes in two different ways.

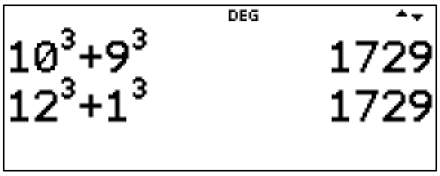
Keystrokes and solution:

(a) Enter **10** and press: [$x^{\square}$] **3** ⓡ [+] **9** [$x^{\square}$] **3** [enter].

$10^3 + 9^3 = 1729$

(b) Press: ⓤ ⓤ [enter] to paste $\mathbf{10^3 + 9^3}$ onto a new author line, use ⓛ and ⓡ to edit the expression as required and Press: [enter].

$12^3 + 1^3 = 1729$



Press [2nd] [√] to calculate the square root of a non-negative value.
[In complex number modes, **a+bi** and **r∠θ** , press [2nd] [√] to calculate the square root of a negative real value.]

Press [2nd] [$^{\square}\sqrt{}$] to calculate the xth root of any non-negative value and any odd integer root of a negative value.

Example: Finding the xth root of a non-negative value

This example shows how to use a calculator to find the xth root of a non-negative value.

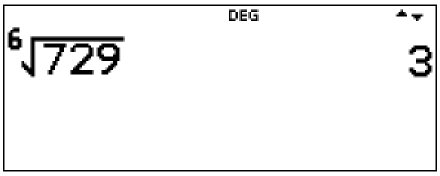
Use the TI-30X Plus MathPrint to calculate $\sqrt[6]{729}$.

Teacher Note: Students should recognise that 3 raised to the power of 6 gives 729.

Keystrokes and solution:

Enter **6** and press [2nd] [$^{\square}\sqrt{}$] **729** [enter].

$\sqrt[6]{729} = 3$



Press [$\frac{1}{\square}$] to calculate the reciprocal of a value.

Example: Finding the reciprocal of a fraction

This example shows how to use a calculator to verify numerically that $\left(\frac{a}{b}\right)^{-1} = \frac{b}{a}$ for $a = 5$ and $b = 7$.

Use the TI-30X Plus MathPrint to calculate the reciprocal of $\frac{5}{7}$. Give your answer as a

(a) fraction. (b) decimal.

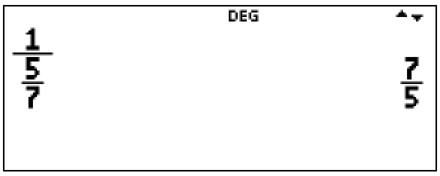
Teacher Note: Students need to recognise that the reciprocal of $\frac{a}{b}$ is $\left(\frac{a}{b}\right)^{-1}$ or $\frac{1}{\frac{a}{b}} = \frac{b}{a}$.

Keystrokes and solution:

(a) Enter **5** and press [$\frac{\square}{\square}$] **7** and press ⓡ [2nd] [$\frac{1}{\square}$] [enter].

$$\frac{1}{\frac{5}{7}} = \left(\frac{5}{7}\right)^{-1} = \frac{7}{5}$$

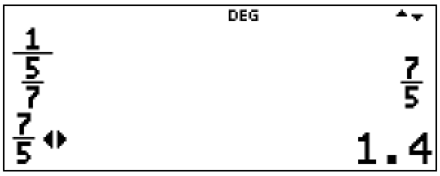
Note: The vinculum between 1 and 5 is larger than the vinculum between 5 and 7 in the original calculation.



Press: [◂▸≈] to express as a decimal.

$$\left(\frac{5}{7}\right)^{-1} = 1.4$$

Alternatively, press [2nd] [f◂▸d] (convert fraction to decimal) [enter].



1.5 Pi (symbol π)

The TI-30X Plus MathPrint can be used to perform calculations involving π.

To access π, press [π e i] (a multi-tap key).

Note that $\pi \approx 3.14159265359$ for calculations and $\pi \approx 3.141592654$ for display in **Float** mode.

Example: Area of a circle

This example shows how to use a calculator to find the area of a circle given its radius and the radius of a circle given its area.

Use the TI-30X Plus MathPrint to find

(a) the area of a circle whose radius is 8 cm. Give your answer correct to one decimal place.

(b) the radius of a circle whose area is 60 m². Give your answer correct to one decimal place.

Teacher Note: When using technology, students need to have a sense of the magnitude of the expected answer. Hence students need to carefully monitor their calculations when using a calculator.

Keystrokes and solution:

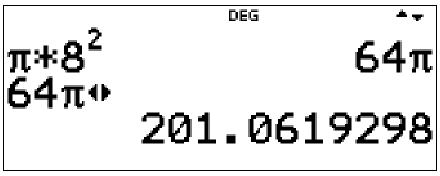
(a) $A = \pi r^2$

Press: [π e i] [×] and enter 8 [x^2] [enter].

$A = 64\pi$ (cm²)

Press: [◂▸≈] to convert to a decimal.

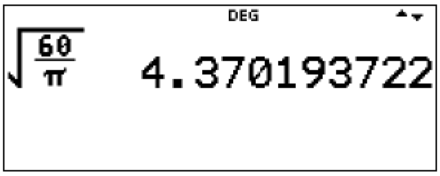
$A = 201.1$ (cm²) correct to 1 decimal place.



(b) $60 = \pi r^2$ and so $r = \sqrt{\frac{60}{\pi}}$ $(r > 0)$

Press: [2nd] [√] [fraction] and enter **60** [▽] [π e i] [enter].

r = 4.4(m) correct to 1 decimal place.



2 Functions

2.1 Working with functions (MA-F1)

2.1.1 Algebraic techniques

Example: Index laws

This example shows how to use a calculator to verify an index law numerically, namely, that $a^{\frac{m}{n}} = \sqrt[n]{a^m}$, where the base a is any positive real number and m and n are positive integers.

Use the TI-30X Plus MathPrint to verify that $81^{\frac{3}{4}} = \sqrt[4]{81^3}$.

Teacher Note: Students need to understand how to use the index laws to show that $a^{\frac{m}{n}} = \sqrt[n]{a^m}$ and to move freely between both representations.

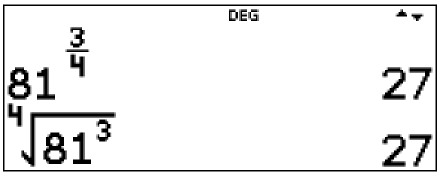
Keystrokes and solution:

Enter **81** and press [$x^{\square}$] [$\frac{\square}{\square}$] **3** [▽] **4** [enter].

$81^{\frac{3}{4}} = 27$

Enter **4** and press [2nd] [$\sqrt[\square]{\ }$] **81** [$x^{\square}$] **3** [enter].

$\sqrt[4]{81^3} = 27$ and $81^{\frac{3}{4}} = \sqrt[4]{81^3}$



The square roots of many numbers are irrational. An irrational number that is the root of a rational number is called a surd. A surd is an irrational number of the form $\sqrt[n]{x}$ where x is a rational number and n is an integer such that $n \geq 2$.

Example: Surds (1)

This example shows how to use a calculator to simplify a surdic expression.

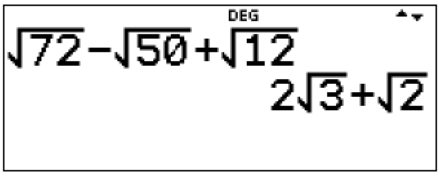
Use the TI-30X Plus MathPrint to simplify $\sqrt{72} - \sqrt{50} + \sqrt{12}$.

Teacher Note: Students need to be able to perform such simplifications, involving the collecting of like terms, without using a calculator.

Keystrokes and solution:

Press: [2nd] [$\sqrt{\ }$] and enter **72** [▷] [−] [2nd] [$\sqrt{\ }$] **50** [▷] [+] [2nd] [$\sqrt{\ }$] **12** [enter].

$\sqrt{72} - \sqrt{50} + \sqrt{12} = 2\sqrt{3} + \sqrt{2}$



Example: Surds (2)

This example shows how to use a calculator to verify the equivalence of two surdic expressions.

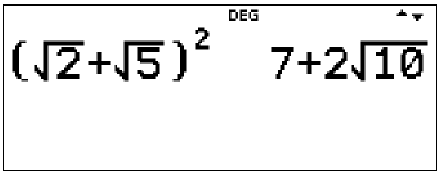
Use the TI-30X Plus MathPrint to verify that $\left(\sqrt{2} + \sqrt{5}\right)^2 = 7 + 2\sqrt{10}$.

Teacher Note: It is important to connect operations with surdic expressions to algebraic techniques such as binomial expansions.

Keystrokes and solution:

Press: [(] [2nd] [$\sqrt{\ }$] and enter **2** [▷] [+] [2nd] [$\sqrt{\ }$] **5** [▷] [)] [x^2] [enter].

$\left(\sqrt{2} + \sqrt{5}\right)^2 = 7 + 2\sqrt{10}$



Example: Surds (3)

This example shows how to use a calculator to rationalise a denominator.

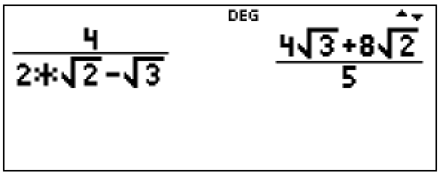
Use the TI-30X Plus MathPrint to express $\dfrac{4}{2\sqrt{2}-\sqrt{3}}$ with a rational denominator.

Teacher Note: When the denominator involves two terms (one or both involving a surd), ensure that students understand that rationalising the denominator involves the use of the difference of two squares identity $(A+B)(A-B)=A^2-B^2$.

Keystrokes and solution:

Enter **4** and press [n/d] **2** [×] [2nd] [√] **2** [▶] [−] [2nd] [√] **3** [enter].

$$\frac{4}{2\sqrt{2}-\sqrt{3}}=\frac{4\sqrt{3}+8\sqrt{2}}{5}$$



Example: Use of the quadratic formula

This example shows how to use a calculator to solve a quadratic equation using the quadratic formula.

Use the quadratic formula and the TI-30X Plus MathPrint to solve $x^2-x-3=0$ for $x>0$. Give your answer

(a) in exact form.

(b) correct to three decimal places.

Teacher Note: Students should recognise that only the positive solution is required.

Keystrokes and solution:

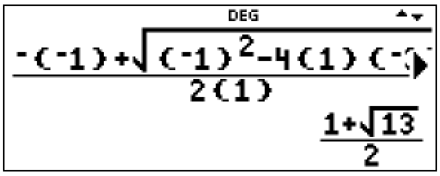
The quadratic formula is $x=\dfrac{-b\pm\sqrt{b^2-4ac}}{2a}$.

To solve $x^2-x-3=0$ for $x>0$, substitute $a=1$, $b=-1$ and $c=-3$ into the quadratic formula.

$$x=\frac{-(-1)+\sqrt{(-1)^2-4(1)(-3)}}{2(1)}\quad(x>0)$$

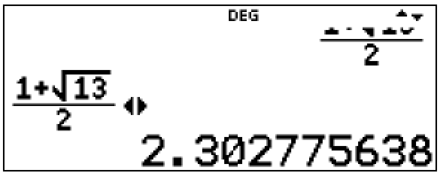
(a) Press: [n/d] [(−)] [(] [(−)] and enter **1** [)] [+] [2nd] [√] [(] [(−)] **1** [)] [x²] [−] **4** [(] **1** [)] [(] [(−)] **3** [)] [▼] **2** [(] **1** [)] [enter].

For $x>0$, $x=\dfrac{1+\sqrt{13}}{2}$.



(b) Press: [◂▸≈] to convert to decimal form.

For $x>0$, $x=2.303$, correct to three decimal places.



2.1.2 Introduction to functions

A function is a set of ordered pairs (x, y) of real numbers such that no two ordered pairs have the same x-coordinate (x-value).

TI-30X Plus MathPrint function feature

Press [table] to access the function table.

The function table menu contains the following options:

1: Add/Edit Func

Lets you define a function $f(x)$ or $g(x)$ or both and generates a table of values.

2: f(

Pastes **f(** to an input area such as the home screen to evaluate the function at a point (for example, **f(5)**).

3: g(

Pastes **g(** to an input area such as the home screen to evaluate the function at a point (for example, **g(2)**).

Press ▼ and ▲ to move around the function table feature.

To set up a function table:

Press [table] [1] to select **Add/Edit Func**. [Press [clear] if required.]

Enter one or two functions as appropriate and press [enter].

TABLE SETUP contains the options **Start**, **Step**, **Auto**, or $x = ?$.

Start: Specifies the starting value for the independent variable, x. It is set to start at **0**.

Step: Specifies the step value for the independent variable, x. The step can be positive or negative but cannot be zero. It is set at **1**.

Auto: Automatically generates a series of values for the dependent variable, y, based on the table start and the table step values.

$x = ?$**:** Lets you build a table manually for the dependent variable, y, by allowing entry of specific values for the independent variable, x.

To display a table, input the desired settings, select **CALC** and press [enter].

In function table view, press [clear] to display and edit the **TABLE SETUP** wizard as needed.

Example: Function as a rule or formula

This example shows how a calculator can be used to solve a question involving a function (quadratic) derived from a likely unfamiliar context.

All people attending a party shook hands with each other as a way of exchanging a greeting. The number of handshakes, N, exchanged between x people at the party is given by the function:

$$N(x) = \frac{x}{2}(x-1) \quad \text{where} \quad x \in \mathbb{Z}^+ .$$

(a) Use the TI-30X Plus MathPrint function feature to find the number of handshakes that would be exchanged between 5, 10 and 50 people respectively.

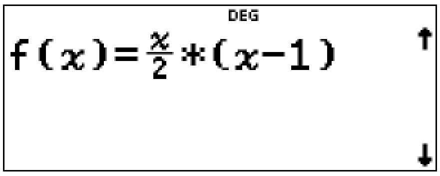
(b) Given that 136 handshakes were exchanged, use the TI-30X Plus MathPrint function feature to determine how many people at the party shook hands.

Teacher Note: It is helpful for students to visualise a function and its rule as a 'machine' with inputs and outputs.

Keystrokes and solution:

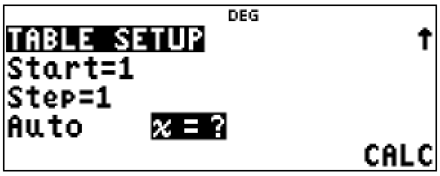
(a) Press: [table] [1] to access the function table.
If required, press [clear].]

Press: [x^{yzt}_{abcd}] to paste x and press [fraction] **2** [►] [×] [(] [x^{yzt}_{abcd}] [−] **1** [)] [▼] [▼].



Move the cursor to select x = **?** press [enter] (**CALC**) [enter].

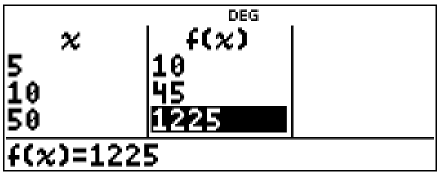
Enter **5** and press [enter] **10** [enter] **50** [enter].



With 5 people, there are 10 handshakes.

With 10 people, there are 45 handshakes.

With 50 people, there are 1225 handshakes.



Alternatively, press [2nd] [quit] to go to the home screen.

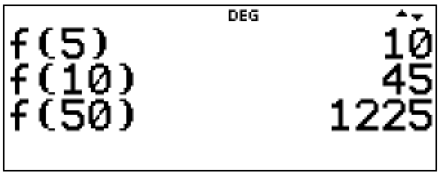
Press [table] [2] and enter **5** [)] [enter].

So f (5) is 10 as before.

Press [▲] [▲] to select **f (5)**. Press [enter].

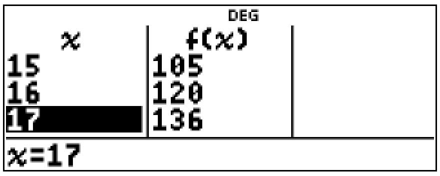
Change **f (5)** to **f (10)** and press [enter].

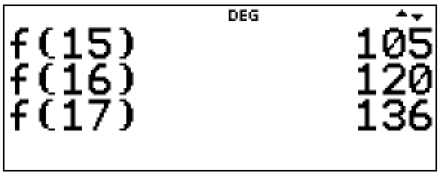
Change **f (10)** to **f (50)** and press [enter]. Thus, confirming our results.



(b) From part (a), we conclude that $x > 10$.

By entering values for x, starting with 15, for example, the last two screenshots show that 17 people exchanged 136 handshakes.





The combined function, $(f \circ g)(x)$, is defined as $f(g(x))$, where the domain is the set of all values in the domain of g for which the output $g(x)$ is in the domain of f.

The combined function, $(g \circ f)(x)$, is defined as $g(f(x))$, where the domain is the set of all values in the domain of f for which the output $f(x)$ is in the domain of g.

Example: Composite functions

This example shows how to use a calculator to find numerical values of composite functions.

Let $f(x) = 4x$ and $g(x) = \sqrt{x}$.

(a) Use the TI-30X Plus MathPrint function feature to find the values of

(i) $f(g(25))$

(ii) $g(f(25))$

(b) Show that $f(g(x)) = 2g(f(x))$.

Teacher Note: It is helpful for students to combine the two functions by placing their function machines so that the output of the first function is the input of the second function.

Keystrokes and solution:

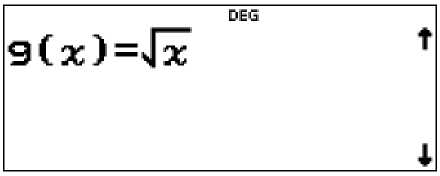
(a) (i) Press: [table] [1] to access the function table.

If required, press [clear].

Enter **4** and press [×] [x^{yzt}_{abcd}] [enter]

[2nd] [√‾] [x^{yzt}_{abcd}] [enter]

Press: [2nd][quit] to return to the home screen.



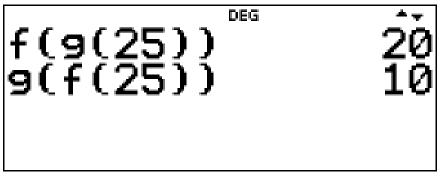
Press: [table] [2] [table] [3] **25** [)] [)] [enter]

$f(g(25)) = 20$

(ii) Press: ▲ ▲ to select **f (g (25))** and press [enter].

Press: [2nd] ◀ to move the cursor to the start of the author line and press [table] [3] [table] [2] [enter].

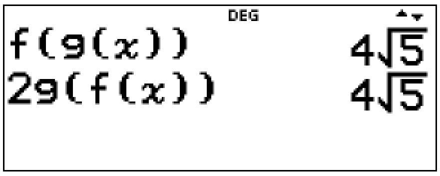
$g(f(25)) = 10$



(b) $f\left(g\left(x\right)\right)=4\sqrt{x}$ and $g\left(f\left(x\right)\right)=2\sqrt{x}$

$2g\left(f\left(x\right)\right)=4\sqrt{x}$

So $f\left(g\left(x\right)\right)=2g\left(f\left(x\right)\right)$.



2.1.3 Linear, quadratic and cubic functions

A linear function, $f(x) = mx + c$, has a graph $y = f(x)$ that is a straight line.

The TI-30X Plus MathPrint can be used to model, analyse and solve problems involving linear functions.

Example: Linear functions (1)

This example shows how to use a calculator to solve a problem involving a linear function.

Daisy's car has a petrol tank with a capacity of 54 litres. Her car's average fuel consumption is 6 litres/100 km. She fills the petrol tank to capacity and drives 700 km to stay with friends.

Let L litres be the amount of petrol remaining in the car's petrol tank after travelling x hundred kilometres. For example, $x = 1$ denotes a travel distance of 100 km.

(a) Find L, as a function of x.

(b) Interpret, in context, the coefficient of x and the constant value found in part (a).

(c) Use the TI-30X Plus MathPrint function feature to calculate

(i) how much petrol was left in the tank when Daisy arrived at her friend's house.

(ii) the maximum distance Daisy's car can travel before running out of petrol.

Teacher Note: Students need to be able to formulate a linear function from worded information. It is also important that students understand the meaning, in context, of m and c in the linear function $f(x) = mx + c$.

Keystrokes and solution:

(a) $L(x) = 54 - 6x$

(b) $m = {}^{-}6$ represents 6 litres of fuel being *used* per 100 km.

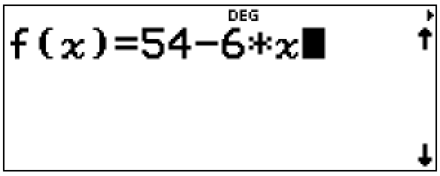
$c = 54$ represents the initial amount of fuel in the car's petrol tank.

(c) (i) A distance of 700 km corresponds to $x = 7$.

Press: [table] [1] to access the function table.

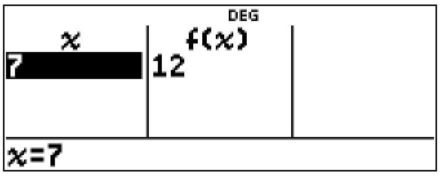
If required, press [clear].

Enter **54** and press [−] **6** [×] [x^{yzt}_{abcd}] to paste x.



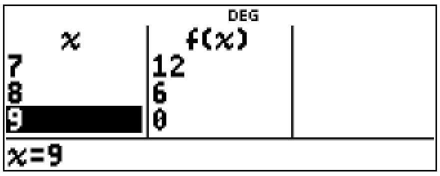
Press ⊝ ⊝. Move the cursor to select x = **?** and press [enter] (**CALC**) [enter]. Enter **7** and press [enter].

$L\,(7) = 12$ and so Daisy had 12 litres in her petrol tank when she arrived at her friend's house.



(ii) Enter guess(es) for the value of x and press [enter].

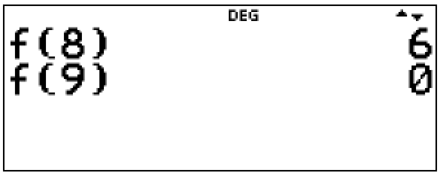
$L\,(8) = 6,\;\; L\,(9) = 0$



Alternatively, press [2nd] [quit] to go to the home screen.

Press [table] [2] and enter guess(es) for the value of x.

$L\,(9) = 0$ and so Daisy's car can travel 900 km before running out of petrol.



We now introduce two TI-30X Plus MathPrint features, namely, the data editor and list formulas feature and the stored operations feature.

TI-30X Plus MathPrint data editor and list formulas feature

Press [data] to access the data editor.

Data can be entered in up to three lists (**L1**, **L2** and **L3**). Each list can contain up to 50 items.

When editing a list, press [data] to access the **CLR**, **FORMULA** and **OPS** menus.

Use ◀ ▶ ⊜ ⊝ to select a cell in the data editor and then enter a value.

Mode settings affect the display of a cell value. Fractions, radicals and π values will display.

Press:

[sto→] to store the value of the cell to a variable.

[◂▸≈] to toggle the number format when a cell is highlighted.

[delete] to delete a cell.

[enter] [clear] to clear the edit line of a cell.

[2nd] [quit] to return to the home screen.

[2nd] ⊜ to go to the top of a list.

[2nd] ⊝ to go to the bottom of a list.

Use the CLR menu to clear the data from a list or lists.

FORMULA menu:

In the data editor, press [data] ▶ to display the FORMULA menu. Select the appropriate menu item to add or edit a list formula in the highlighted column or clear formulas from a particular list.

When a data cell is highlighted, pressing [sto→] is a shortcut to open the formula edit state.

In the formula edit state, pressing [data] displays a menu to paste **L1**, **L2** or **L3** in the formula.

Formulas cannot contain a circular reference such as **L1** = **L1** or **L1** = **f(L3)** and **L3** = **g(L1)**

When a list contains a formula, the edit line will display the reversed cell name. Cells will update if referenced lists are updated.

To clear a formula list, clear the formula first and then clear the list.

If [sto→] is used in a list formula, the last element of the computed list is stored to the variable. Lists cannot be stored.

List formulas accept all TI-30X Plus MathPrint functions and real numbers.

Options (OPS menu):

In the data editor, press [data] ◀ to display the **OPS** menu. This allows you to sort values from smallest to largest or largest to smallest, create a sequence of values to fill a list or sum the elements in a list which can then be stored to a variable for further use.

TI-30X Plus MathPrint stored operations feature

Press [2nd] [set op] to store an operation.

Press [2nd] [op] to paste an operation to the home screen.

To set an operation and then recall it:

Press [2nd] [set op].

Enter any combination of numbers, operations, and/or data values.

Press [enter] to store the operation.

Press [2nd] [op] to recall the stored operation and apply it to the last answer or the current entry.

If you apply [2nd] [op] directly to a [2nd] [op] result, a $\mathbf{n} = \mathbf{1}$ iteration counter is incremented.

Example: Linear functions (2)

The TI-30X Plus MathPrint data editor and list formulas feature, and the stored operations feature can both be used to solve problems involving linear functions. This example could also be solved using the function feature and, of course, the conversions feature.

On a particular July day, a weather forecast listed the following predicted maximum temperatures.

Canberra 13°C

Sydney 18°C

Thredbo 2°C

The function $F(C) = \frac{9}{5}C + 32$ can be used to convert degrees Celsius to degrees Fahrenheit.

(a) Convert these temperatures from degrees Celsius to degrees Fahrenheit using the TI-30X Plus MathPrint

(i) data editor and list formulas feature.

(ii) stored operations feature.

(b) If Katoomba is predicted to have a maximum temperature of 9°C, use the TI-30X Plus MathPrint to convert this temperature to degrees Fahrenheit.

Teacher Note: This example showcases the different ways that the TI-30X Plus MathPrint can be used to solve these types of problems.

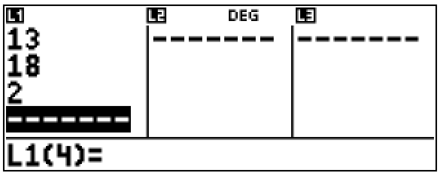
Keystrokes and solution:

(a) (i) Using the data editor and list formulas feature:

Press: [data] then [data] [4] to clear all lists.

Enter **13** and press [⌄]. Repeat for **18** and **2**.

The three temperatures should now be displayed in **L1**.

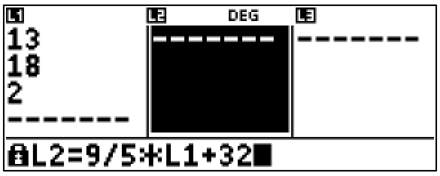


Press [>] to scroll across to the top of **L2**. Press [data] [>] to select **FORMULA** and press [1].

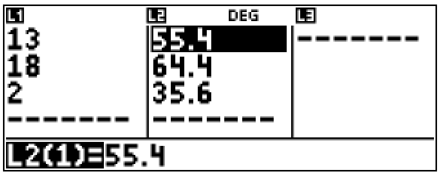
Enter the temperature conversion formula to **L2**.

Enter $\frac{9}{5}$ using the division key to ensure decimal outputs.

Enter **9** and press [÷] **5** [×]. Press [data] [enter] to paste **L1** into the author line. Press [+] and enter **32** [enter].



L2 should now display the converted temperatures 55.4°F,
64.4 °F and 35.6 °F.

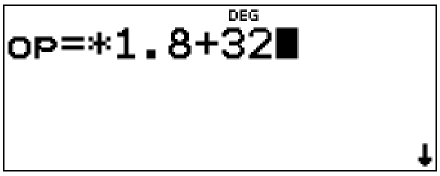


(a) (ii) Using the stored operations feature:

Press [2nd] [set op].

If required, press [clear] to clear previously stored operations.

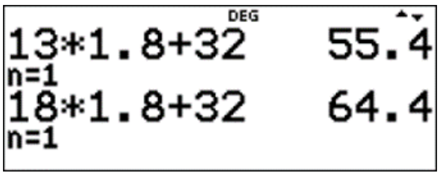
Press [×] and enter **1.8** [+] **32** [enter].



Enter **13** and press [2nd] [op].

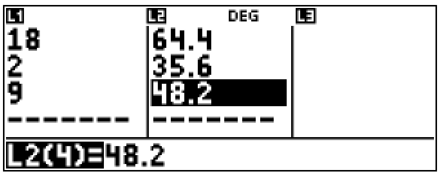
Repeat for **18** and **2**.

The three converted temperatures are 55.4°F, 64.4 °F and 35.6 °F



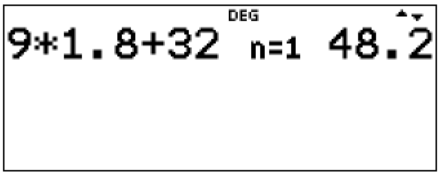
(b) Using the data editor and list formulas feature, press: [data]. Move to **L1(4)** =, enter **9** and press [enter].

L2 should now display Katoomba's converted temperature of 48.2°F.



Using the stored operations feature:

Press [2nd] [quit]. Enter **9** and press [2nd] [op].



A quadratic function, $f(x)$, has a graph $y = f(x)$ that is a parabola.

The TI-30X Plus MathPrint can be used to model, analyse, and solve problems involving quadratic functions.

Example: Quadratic functions (1)

This example shows how to use a calculator to find the coordinates of the vertex (turning point) of a parabola.

Use the TI-30X Plus MathPrint function feature to find the vertex of the parabola $y = x(12 - x)$.

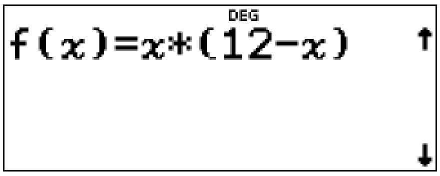
Teacher Note: Using the TI-30X Plus MathPrint function feature in this way can help to reinforce to students that the vertex of a parabola is the point on its axis of symmetry. This example could be reframed to ask for the x-coordinate of a point on a parabola given that the y-coordinate is 36.

Keystrokes and solution:

Press: [table] [1] to access the function table.

If required, press [clear].

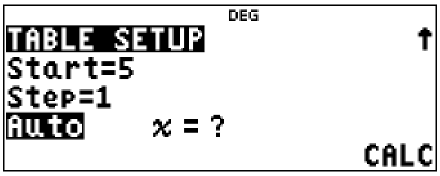
Press [x^{yzt}_{abcd}] to paste x and press [×] [(] **12** [−] [x^{yzt}_{abcd}] [)] ⊝ ⊝.



Enter **5** for **Start** and press ⊝.

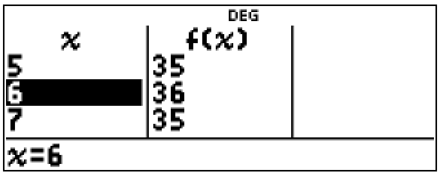
Enter **1** for **Step** and press ⊝.

Select **Auto** and press [enter] (**CALC**) [enter].



After searching close to $x = 6$, the point (6, 36) appears to be the vertex of the parabola as 36 appears to be the maximum y-coordinate.

Note: To search closer to $x = 6$, change the step value to see the coordinates of points closer to, and either side of, (6,36).



TI-30X Plus MathPrint expression evaluation feature

Press [2nd] [expr-eval] to input and calculate an expression using numbers, functions and variables/parameters.

Pressing [2nd] [expr-eval] from a populated home screen expression pastes the content to **Expr =**.

If variables ***x, y, z, t, a, b, c*** and ***d*** are used in the expression, you will be prompted for values or use the stored values displayed for each prompt.

The number stored in the variables will update in TI-30X Plus MathPrint.

Example: Quadratic functions (2)

This example shows how to use the discriminant and a calculator to predict the number and nature of x-intercepts for a quadratic graph.

Use the discriminant and the TI-30X Plus MathPrint expression evaluation feature to predict the number and nature of x-intercepts for the graph of $y = 2x^2 + 9x - 5$.

Teacher Note:

Case 1: If $b^2 - 4ac > 0$, the graph of $y = ax^2 + bx + c$ has two x-intercepts, $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$,

which are rational if $b^2 - 4ac$ is a perfect square and irrational otherwise.

Case 2: If $b^2 - 4ac = 0$, the graph of $y = ax^2 + bx + c$ has exactly one x-intercept, $x = -\dfrac{b}{2a}$.

Case 3: If $b^2 - 4ac < 0$, the graph of $y = ax^2 + bx + c$ has no x-intercepts.

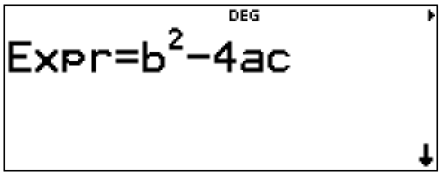
Keystrokes and solution:

Press: [2nd] [expr-eval].

If required, press [clear].

[x^{yzt}_{abcd}] is a multi-tap key that cycles through variables ***x, y, z, t, a, b, c*** and ***d***.

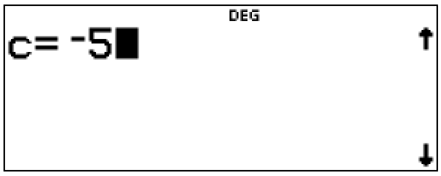
Press [x^{yzt}_{abcd}] until ***b*** appears. Press [x^2] [−] **4** then press [x^{yzt}_{abcd}] until ***a*** appears, now press: [▶] to release the multi-tap functionality, and continue to press [x^{yzt}_{abcd}] until ***c*** appears.



Press: [enter] [clear] and enter **9**.

Press: [enter] [clear] and enter **2**.

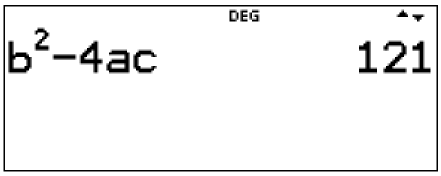
Press: [enter] [clear] [(−)] and enter **5** [enter].



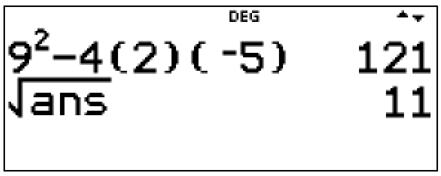
Substituting $a = 2$, $b = 9$ and $c = -5$ into $b^2 - 4ac$ gives $9^2 - 4(2)(-5) = 121$.

The discriminant is 121.

Since the discriminant is 11^2, there are two rational x-intercepts, $\left(x = -5, \dfrac{1}{2}\right)$.



Alternatively, calculate the discriminant as shown at right.



Simultaneous equations where one equation is non-linear can be solved using algebraic, graphical, or numerical techniques.

Simultaneous equations, with integer solutions, can be solved using a table of values.

Example: Linear and quadratic functions

This example shows how to use a calculator to solve a pair of simultaneous equations where one equation is non-linear. This example could also be solved using the TI-30X Plus MathPrint function feature.

Use the TI-30X Plus MathPrint data editor and list formulas feature to solve the pair of simultaneous equations $y = 2x - 3$ and $y = -x^2$.

Teacher Note: Encourage students to sketch the two graphs on the same set of axes to determine the approximate location of the points of intersection. This helps to construct a table of values that contains the solutions to the equations. Students should relate the solutions found to the intersection points of their graphs.

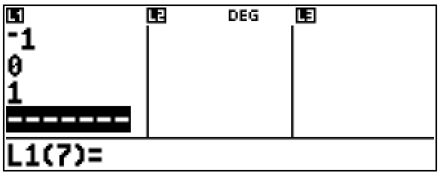
Keystrokes and solution:

Press [data].

Press [data] [4] to clear all lists.

Note: Press [(–)] to enter a negative number.

In **L1** enter **-4** and press (▼). Enter the values **-3**, **-2**, **-1**, **0**, and **1**. These six x-values should now be displayed in **L1**.

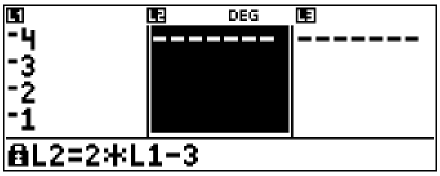


Press (▶) to navigate across to the top of **L2**.

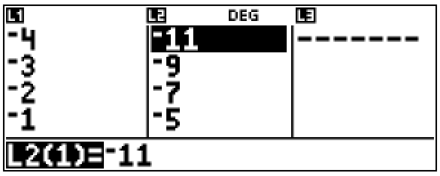
Press [data] (▶) to select **FORMULA** and press [enter].

Enter the list formula **2 *L1 – 3** to **L2**.

Enter **2** and press [×]. Press [data] [enter] to paste **L1** into the author line. Press [−] and enter **3** [enter].



L2 should now display the function values -11, -9, -7. -5, -3, -1.



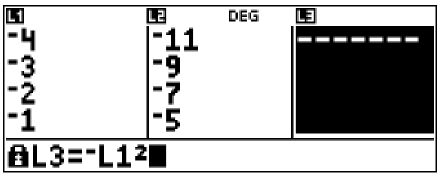
Press (▶) to scroll across to the top of **L3**.

Press [data] (▶) to select **FORMULA** and press [enter].

Enter the list formula **–L1²** to **L3**.

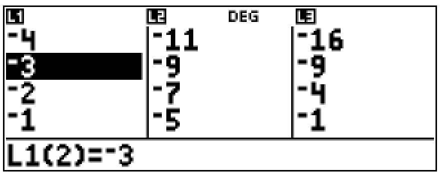
Press [(–)] and press [data] [enter] to paste **L1** into the author line.

Press [x^2] [enter].



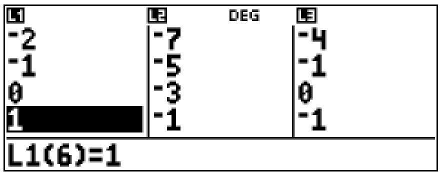
L3 should now display the function values -16, -9, -4, -1, 0, 1.

From the lists, it can be concluded that **L2 = L3** for $x = -3$ and $x = 1$.



The solutions are $x = {}^{-}3$ and $y = {}^{-}9$ or $x = 1$ and $y = {}^{-}1$.

Hence the two graphs intersect at $({}^{-}3, {}^{-}9)$ and $(1, {}^{-}1)$.



2.1.4 Further functions and relations

A polynomial, $P(x)$, can be expressed in the form: $P(x) = a_n x^n + a_{n-1}x^{n-1} + a_{n-2}x^{n-2} + \ldots a_1 x + a_0$ where the coefficients $a_n.\ a_{n-1},\ a_{n-2},\ ..a_1,\ and\ a_0$ are real numbers and n is either a positive integer or zero.

The degree of $P(x)$ is n for $a_n \neq 0$ and is given by the highest power of x.

The coefficient of the highest power of $P(x)$ is the leading coefficient. Hence a_n is the leading coefficient.

The term that is independent of x is the constant term. Hence a_0 is the constant term.

A monic polynomial has a leading coefficient that is equal to 1. Hence a monic polynomial has the form:
$P(x) = x^n + a_{n-1}x^{n-1} + a_{n-2}x^{n-2} + \ldots a_1 x + a_0$

Numerical substitution into $P\ (x)$ means replacing x by a number and evaluating or simplifying the result. So $P(c)$ is the value of $P(x)$ for $x = c$.

Short investigation: Polynomials

This short investigation shows how to use a calculator to consider a different way of determining the coefficients of a polynomial. It is limited to polynomials with single-digit non-negative coefficients.

With the TI-30X Plus MathPrint, press [e□10□] [e□10□] (a multi-tap key) to raise 10 to the power you specify.

(a) Use the TI-30X Plus MathPrint to evaluate $P\ (10)$ for each of the following:

(i) $P\ (x) = 6x + 4$

(ii) $P\ (x) = x^2 + 3x + 9$

(iii) $P\ (x) = 5x^2 + 2x + 5$

(iv) $P\ (x) = 3x^3 + 2x^2 + 8x + 1$

(b) Use part (a) to suggest a rule relating $P(10)$ to the coefficients of $P(x)$.

(c) Hence determine $P\ (x)$ in each of the following cases

(i) $P\ (10) = 87$ where $P\ (x)$ is a polynomial of degree 1.

(ii) $P\ (10) = 924$ where $P\ (x)$ is a polynomial of degree 2.

(iii) $P\ (10) = 5869$ where $P\ (x)$ is a polynomial of degree 3.

Teacher Note: Such investigations show how the TI-30X Plus MathPrint can be used for good teaching and learning opportunities. This investigation can be extended to polynomials with two-digit non-negative coefficients and more generally, to k-digit non-negative coefficients.

Answers:

(a) (i) $P(10) = 64$

(ii) $P(10) = 139$

(iii) $P(10) = 525$

(iv) $P(10) = 3281$

(b) For single-digit non-negative coefficients: $a_n 10^n + a_{n-1}10^{n-1} + \ldots + a_1 10 + a_0 = a_n a_{n-1} \ldots a_1 a_0$ where $a_n a_{n-1} \ldots a_1 a_0$ is a positive integer consisting of $n+1$ digits, hence the digits of $P(10)$ are the coefficients of $P(x)$.

(c) (i) $P(x) = 8x + 7$

(ii) $P(x) = 9x^2 + 2x + 4$

(iii) $P(x) = 5x^3 + 8x^2 + 6x + 9$

Students are expected to identify the shape and features of graphs of polynomial functions of any degree in factored form and sketch their graphs.

To create a sequence of values to fill a list in the data editor, press [data] ◄ to display the Options (**OPS**) menu. Press [3] and complete the required fields.

Example: Polynomials

This example shows how to use a calculator to construct a table of values which can be used to help sketch the graph of a polynomial function in factored form.

Consider the function: $f(x) = (x + 1)(x - 2)(x - 4)$

Use the TI-30X Plus MathPrint data editor and list formulas feature to complete the following table of values for $f(x) = (x + 1)(x - 2)(x - 4)$.

x	-2	-1	0	1	2	3	4	5
$f(x)$								

Teacher Note: Students should recognise that if a polynomial is in factored form, its basic shape can be established by constructing a table of values to determine its sign. They should also be aware of the behaviour of cubics for large negative and positive values of x.

Keystrokes and solution:

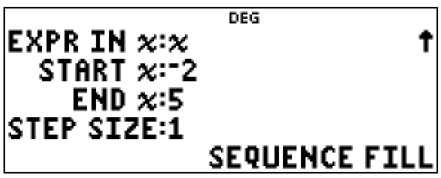
Press [data].

Press [data] [4] to clear all lists.

Press [data] ◄ [3]. Select **L1** and press [enter].

Press [x^{yzt}_{abcd}] to paste x, complete the sequence set-up as shown, scroll down to select **SEQUENCE FILL** and press [enter].

Note: Press [(–)] to enter a negative number.



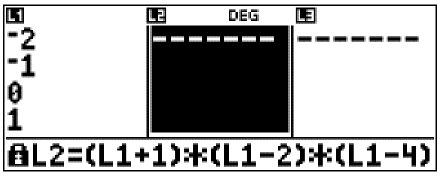
These eight x-values should now be displayed in **L1**.

Press: ⊳ to scroll across to the top of **L2**. Press [data] ⊳ to select **FORMULA** and press [enter].

Enter the list formula **(L1 + 1)*(L1 – 2)*(L1-4)** to **L2**.

Press: [(] [data] [enter] to paste **L1** into the author line.

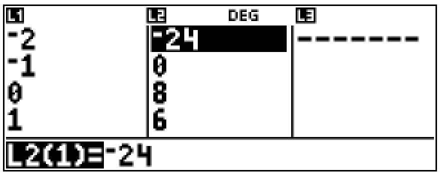
Press: [+] and enter **1** [)] [×] [(] [data] [enter] [–] and enter **2**.
Press: [)] [×] [(] [data] [enter] [–] and enter **4** [)] [enter].

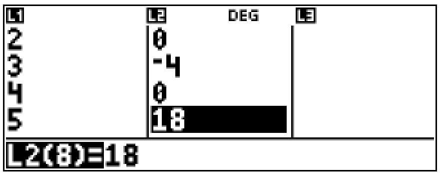


L2 should now display the function values -24, 0, 8, 6, 0, -4, 0, 18 and the table can be completed.

The cubic has zeroes at x = –1, 2 and 4.

As the domain of the function is all real numbers and it is continuous for all x, the zeroes are the only places where the function changes sign.





Functions of the form $f\left(x\right)=\frac{k}{x}$ represent inverse variation.

A variable y varies inversely with a variable x if $y=\frac{k}{x}$, where k is a non-zero constant of proportionality. The graph of y as a function of x is a rectangular hyperbola whose asymptotes are the x-axis and the y- axis.

Example: Inverse variation

This example shows how to use a calculator to help solve a problem involving inverse variation.

In electrical circuits, Ohm's law states that, for a given voltage, the current, I amperes, in an electrical component is inversely proportional to its resistance, R ohms. An electrical component has a resistance of 2.4 ohms and passes a current of 5 amperes when connected to a battery.

If the same battery is used, use the TI-30X Plus MathPrint to find the current passing through an electrical component whose resistance is 1.5 ohms.

Teacher Note: It is important for students to recognise that if R increases then I decreases and if R decreases then I increases.

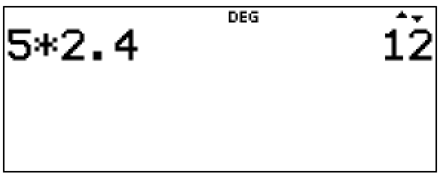
Keystrokes and solution:

$I\propto\frac{1}{R}$ therefore: $I=\frac{k}{R}$ where k is the constant of proportionality.

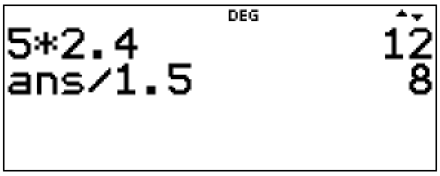
Substitute R = 2.4 and I = 5 into $I=\frac{k}{R}$ and solve to find k therefore: $5=\frac{k}{2.4}$

$$k=5\times 2.4$$

Press: **5** [×] **2.4** [enter]



$k = 12$ and hence $I = \dfrac{12}{R}$.



Substitute: $R = 1.5$ into $I = \dfrac{12}{R}$.

Press: [2nd] [answer] [÷] and enter **1.5** [enter].

$$I = \frac{12}{1.5}$$
$$= 8$$

The current passing through the electrical component is 8 amperes.

Students are expected to use and apply the notation $|x|$ for the absolute value of the real number and recognise the shape of the graph of $y = |x|$.

The absolute value of a real number x, denoted by $|x|$, is the distance from x to the origin on the number line.

$|x| \geq 0$ for $x \in \mathbb{R}$ and $|-x| = |x|$ for $x \in \mathbb{R}$.

For $x \in \mathbb{R}$, $|x| = \begin{cases} x, & x \geq 0 \\ -x, & x < 0 \end{cases}$.

Press [math] ▶ to display the number (**NUM**) menu.

Press [1] to paste **abs(** .

Example: Absolute value

This example shows how to use a calculator to construct a table of values which can be used to help sketch the graph of a function of the form $y = |ax + b|$.

Consider the function $f(x) = |3x + 6|$.

Use the TI-30X Plus MathPrint data editor and list formulas feature to complete the following table of values for $f(x) = |3x + 6|$.

x	-4	-3	-2	-1	0
y					

Teacher Note: Students should recognise that a useful first step is to find the x-intercept and the y-intercept. They should also be aware of the symmetry of the graph.

Keystrokes and solution:

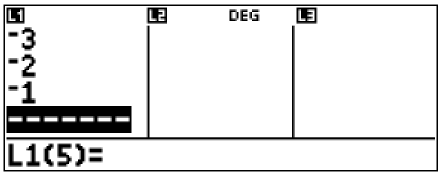
Press: [data].

Press: [data] [4] to clear all lists.

Note: Press [(–)] to enter a negative number.

In **L1** enter **-4** and press ▾. Enter the values **-3**, **-2**, **-1** and **0**.

These five x-values should now be displayed in **L1**.

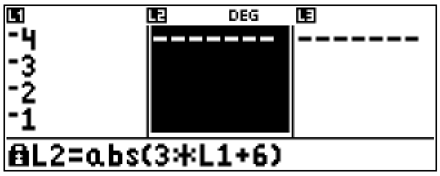


Press ▸ to scroll across to the top of **L2**.

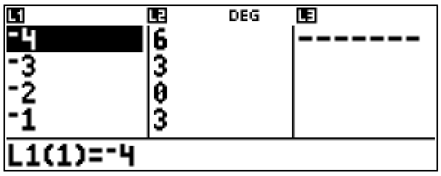
Press [data] ▸ to select **FORMULA** and press [enter].

Enter the list formula **abs(3*L1 + 6)** to **L2**.

Press [math] ▸ [1] **3** [×]. Press [data] [enter] to paste **L1** into the author line. Press [+] and enter **6** [)] [enter].



L2 should now display the function values **6, 3, 0, 3, 6** and the table can be completed.



2.2 Graphing techniques (MA-F2)

Consider functions of the form $y = kf\,(a\,(x + b)) + c$ where $f\,(x)$ is a polynomial, reciprocal, absolute value, exponential or logarithmic function and a, b, c and k are real numbers.

Here we illustrate dilations only. The following two examples, showcasing the data editor and list formulas feature, can be adapted to examine translations involving $y = f\,(x) + c$ and $y = f\,(x + b)$.

The graph of $y = kf\,(x)$ is a dilation of the graph of $y = f\,(x)$ by a factor of k from the x-axis. This is dilation in the vertical direction.

Example: Dilations (1)

This example shows how to use a calculator to construct a table of values which can be used to help students visualise stretching away from the x-axis in the vertical direction.

(a) Use the TI-30X Plus MathPrint data editor and list formulas feature to complete the following table of values for $y = x\,(x - 2)$ and $y = 3x\,(x - 2)$.

x	-2	-1	0	1	2	3	4
$y = x\,(x - 2)$							
$y = 3x\,(x - 2)$							

(b) Describe how the graph of $y = 3x\,(x - 2)$ can be obtained from the graph of $y = x\,(x - 2)$.

Teacher Note: Students need to understand that the x-axis is the axis of dilation. Points on the x-axis do not move. All other points on this dilated graph triple their distance from the x-axis.

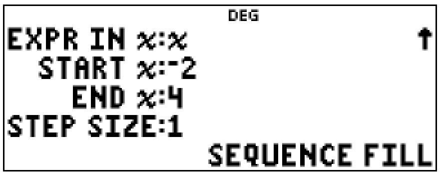
Keystrokes and solution:

(a) Press [data].

Press [data] [4] to clear all lists.

Press [data] ◀ [3]. Select **L1** and press [enter]. Press [$x\frac{yzt}{abcd}$] to paste x, complete the sequence set-up as shown, scroll down to select **SEQUENCE FILL** and press [enter].

Note: Press [(–)] to enter a negative number.



These seven x-values should now be displayed in **L1**.

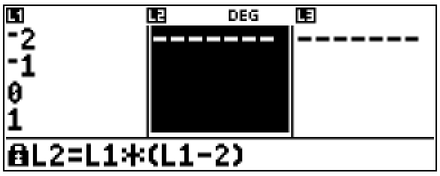
Press: ▶ to scroll across to the top of **L2**.

Press: [data] ▶ to select **FORMULA** and press [enter].

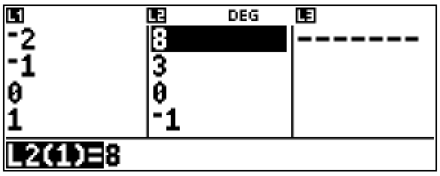
Enter the list formula **L1*(L1 – 2)** to **L2**.

Press: [data] [enter] to paste **L1** into the author line.

Press: [×] [(] [data] [enter] [–] **2** [)] [enter].



L2 should now display the function values 8, 3, 0, -1, 0, 3, 8 and row 2 of the *table* can be completed.

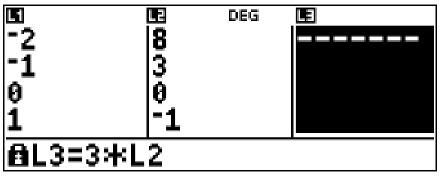


Press: ▶ to scroll across to the top of **L3**.

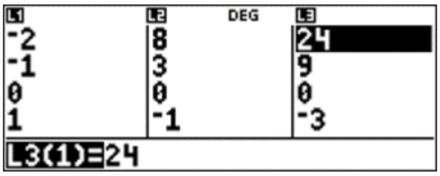
Press: [data] ▶ to select **FORMULA** and press [enter].

Enter the list formula **3*L2** to **L3**.

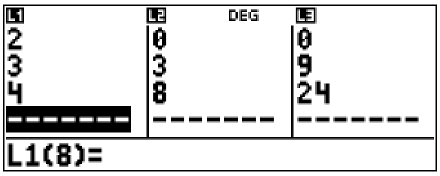
Enter **3** [×] [data] [2] [enter].



L3 should now display the function values 24, 9, 0, -3, 0, 9, 24 and row 3 of the *table* can be completed.



(b) The graph of $y = 3x\,(x - 2)$ is obtained from the graph of $y = x\,(x - 2)$ by stretching away from the x-axis in the vertical direction by a factor of 3



The graph of $y = f\,(ax)$ is a dilation of the graph of $y = f\,(x)$ by a factor of $\frac{1}{a}$ from the y-axis. This is dilation in the horizontal direction.

Example: Dilations (2)

This example shows how to use a calculator to construct a table of values which can be used to help students visualise stretching away from the y-axis in the horizontal direction.

(a) Use the TI-30X Plus MathPrint data editor and list formulas feature to complete the following tables of values for

(i) $y = x\,(x-2)$

x	–2	–1	0	1	2	3	4
y							

(ii) $y = \dfrac{x}{3}\left(\dfrac{x}{3}-2\right)$

x	–6	–3	0	3	6	9	12
y							

(b) Describe how the graph of $y = \dfrac{x}{3}\left(\dfrac{x}{3}-2\right)$ can be obtained from the graph of $y = x\,(x-2)$.

Teacher Note: Students need to understand that the y-axis is the axis of dilation. The point on the y-axis, $(0,0)$, does not move. All other points on this dilated graph triple their distance from the y-axis. To produce the same y-coordinates in each table, the x-coordinates are multiplied by 3.

Keystrokes and solution:

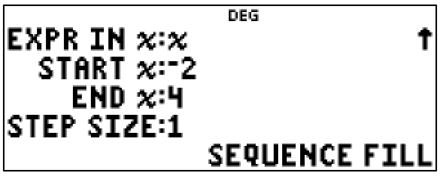
(a) (i) Press [data]

Press [data] [4] to clear all lists.

Press [data] [◄] [3]. Select **L1** and press [enter].

Press [x^{yzt}_{abcd}] to paste x, complete the sequence set-up as shown, scroll down to highlgiht **SEQUENCE FILL** and press [enter].

Note: Press [(–)] to enter a negative number.



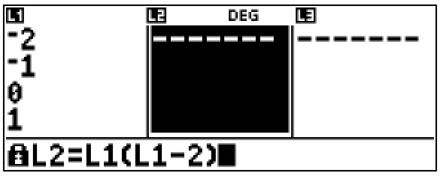
These seven x-values should now be displayed in **L1**.

Press [►] to scroll across to the top of **L2**. Press [data] [►] to select **FORMULA** and press [enter].

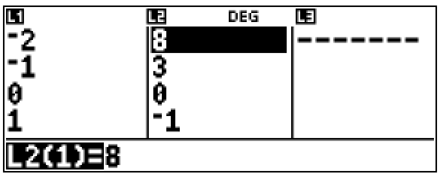
Enter the list formula **L1*(L1 – 2)** to **L2**.

Press [data] [enter] to paste **L1** into the author line.

Press [×] [(] [data] [enter] [−] **2** [)] [enter].



L2 should now display the function values **8**, **3**, **0**, **-1**, **0**, **3**, **8** and the table can be completed.



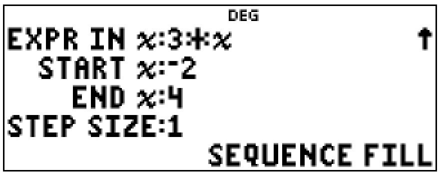
(a) (ii) Move to the top of **L1**.

Press [data] ◀ [3]. Select **L1** and press [enter].

Enter **3** and press [×].

Press [$x\frac{yzt}{abcd}$] to paste x, complete the sequence set-up as shown, scroll down to select **SEQUENCE FILL** and press [enter].

Note: Press [(–)] to enter a negative number.



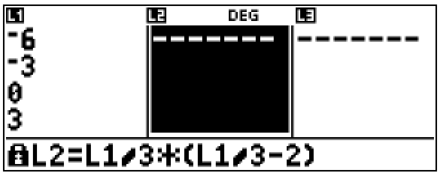
These seven x-values should now be displayed in **L1**.

Press ▶ to scroll across to the top of **L2**. Press [data] ▶ to select **FORMULA** and press [enter].

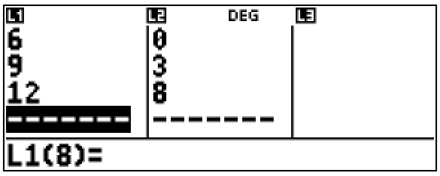
Enter the list formula **L1/3*(L1/3-2)** to **L2**.

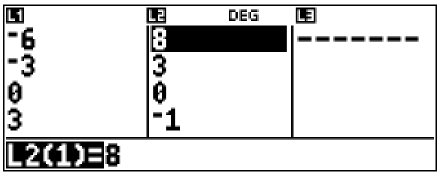
Press [data] [enter] to paste **L1** into the author line.

Press [÷] and enter **3** [×] [(] [data] [enter] [÷] **3** [–] **2** [)] [enter].



L2 should now display the function values **8**, **3**, **0**, **-1**, **0**, **3**, **8** and the table can be completed.





(b) The graph of $y = \frac{x}{3}\left(\frac{x}{3} - 2\right)$ is obtained from the graph of

$y = x\,(x - 2)$ by stretching away from the y-axis in the horizontal direction by a factor of 3. Students are expected to solve linear and quadratic inequalities.

Example: Solving linear inequalities

This example shows how to use a calculator to solve a linear inequality

Use the TI-30X Plus MathPrint data editor and list formulas feature to solve the inequality $6\,(x + 4) \geq 12$.

Teacher Note: Students should verify numerically the direction of the inequality sign by substituting a known value that is within the solution range.

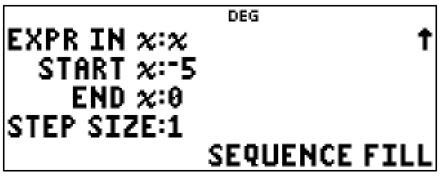
Keystrokes and solution:

Press [data] [data] [4] to clear all lists.

Press [data] ◀ [3]. Select **L1** and press [enter].

Press [$x\frac{yzt}{abcd}$] to paste x, complete the sequence set-up as shown, scroll down to select **SEQUENCE FILL** and press [enter].

Note: Press [(–)] to enter a negative number.



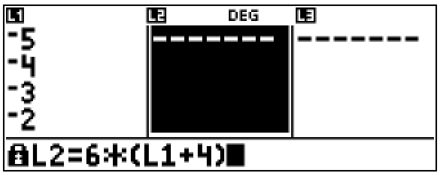
These six x-values should now be displayed in **L1**.

Press [►] to scroll across to the top of **L2**.

Press [data] [►] to select **FORMULA** and press [enter].

Enter the list formula $6*(\mathbf{L1}+4)$ to **L2**.

Enter **6** and press [×] [(] [data] [enter] to paste **L1** into the author line. Press [+] and enter **4** [)] [enter].

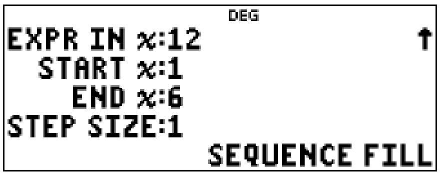


L2 should now display the function values **-6**, **0**, **6**, **12**, **18**, **24**.

Press [►] to scroll across to the top of **L3**.

Use the sequence feature to enter **12** six times in **L3**.

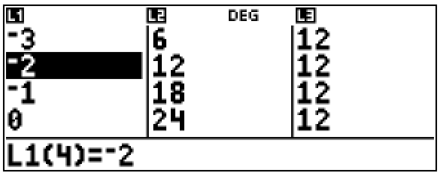
Complete the sequence set-up as shown, scroll down to select **SEQUENCE FILL** and press [enter].



These six values should now be displayed in **L3**.

From the lists, it can be concluded that $6\,(x+4) \geq 12$ for $x \geq -2$.

Note that for $x < -2$, $6\,(x+4) < 12$.



Students need to be able to use trial and error to solve equations that cannot be solved algebraically.

Example: Solving an equation by trial and error

This example shows how to use a calculator to solve an equation using trial and error.

Use the TI-30X Plus MathPrint data editor and list formulas feature to solve the equation $2^x = x^2$ for $x < 0$. Give your answer correct to three decimal places.

Teacher Note: Students should recognise there are three solutions to this equation. The other two (integer) solutions, $x = 2, 4$, can be obtained readily by inspection as $4^2 = 2^4 = 16$. Sketching the graphs of $y = x^2$ and $y = 2^x$ and noting the approximate location of the intersection point for $x < 0$ will inform a sensible initial x-value. The TI-30X Plus MathPrint function feature can also be used here.

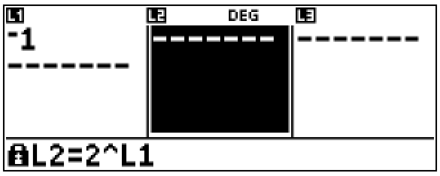
Keystrokes and solution:

Press [data].

Press [data] [4] to clear all lists.

[**Note**: Press [(–)] to enter a negative number.]

In **L1**, enter **-1** as an initial guess and press [▼].

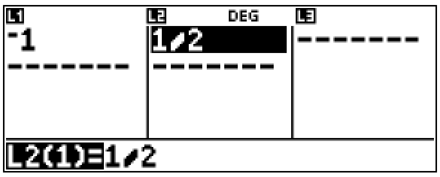


Press [►] to scroll across to the top of **L2**. Press [data] [►] to select **FORMULA** and press [enter].

Enter the list formula $2 \wedge \mathbf{L1}$ to **L2**.

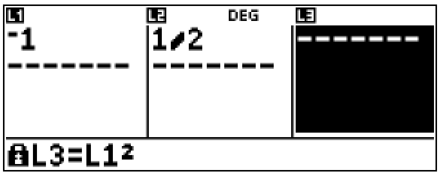
Enter **2** and press [$x^{\square}$] [data] [enter] to paste **L1** into the author line and press [enter].

1 / 2 should now be displayed in **L2**.

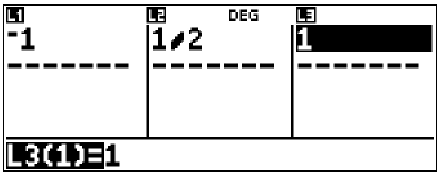


Press ⏵ to scroll across to the top of **L3**. Press [data] ⏵ to select **FORMULA** and press [enter].

Enter the list formula $\mathbf{L1}^2$ to **L3**.



Press [data] [enter] [x^2] [enter]. **1** should now be displayed in **L3**.



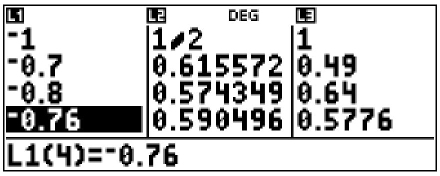
Move to $\mathbf{L1(2)}$ = and enter an appropriate guess for the x-value, for example, **-0.7**. Press [enter].

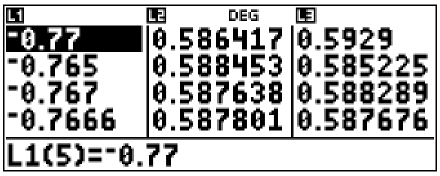
Continue to enter x-values that (hopefully) approach the required solution. After each x-value is entered, press [enter].

The two screenshots at right show a set of x-values used to determine the solution correct to three decimal places.

For $x = –0.767$, $2^x < x^2$, and for $x = –0.7666$, $2^x > x^2$, (a sign change has occurred).

So, correct to three decimal places, $x = –0.767$.





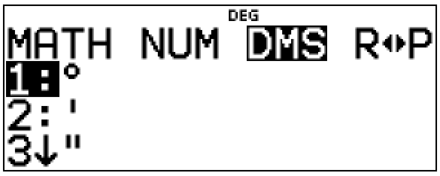
3 Trigonometric functions

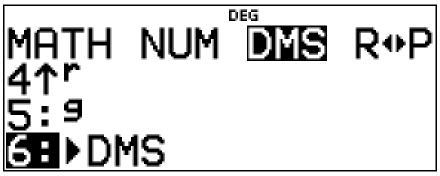
3.1 Trigonometry and measure of angles (MA-T1)

3.1.1 Trigonometry

Press [mode] to choose an angle mode from the mode screen. Note that **DEG** is the default.

Press [math] ⏵ ⏵ to display the **DMS** menu.





This menu enables you to specify the angle unit modifier as degrees (°), minutes (‘), seconds (“); specify a radian angle (**r**); specify a gradian angle (**g**), or convert an angle from decimal degrees to degrees, minutes and seconds using ▶ **DMS**.

Inputs are interpreted and results displayed according to the angle mode setting without the need to enter an angle unit modifier.

Example: Degrees and radians mode (1)

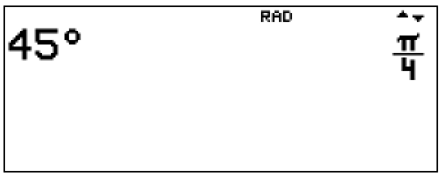
Use the TI-30X Plus MathPrint in radian mode to convert 45° to radians, students need to know that $180 = \pi^c$.

Keystrokes and solution:

Press [mode], select **RADIAN** and press [enter].

Enter **45** and press [math] ⏵ ⏵ [1] [enter].

$$45° = \frac{\pi^c}{4}$$



Example: Degrees and radians mode (2)

Use the TI-30X Plus MathPrint in degree mode to convert 2π radians to degrees.

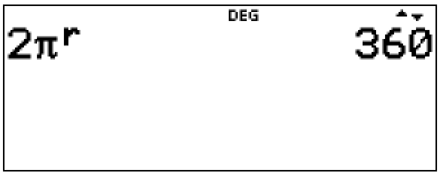
Teacher Note: Students need to know that $2\pi^c = 360°$.

Keystrokes and solution:

To be in degree mode, press [mode], select **DEGREE** and press [enter].

Enter **2** and press [π] [math] ▶ ▶ [4] [enter].

$2\pi^c = 360°$



Example: Converting an angle from decimal degrees to degrees and minutes

This example shows how to use a calculator to convert an angle from a decimal to degrees and minutes.

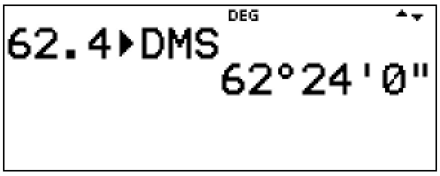
Use the TI-30X Plus MathPrint to convert $62.4°$ to an angle expressed in degrees and minutes.

Teacher Note: It is useful for students to know that $0.1°$ corresponds to $6'$.

Keystrokes and solution:

Enter **62.4** and press [math] ▶ ▶ [6] [enter].

$62.4° = 62°24'$



Students are expected to use the sine, cosine and tangent ratios to solve problems in two and three dimensions involving right-angled triangles where angles are measured in degrees, or degrees and minutes. This can include solving practical problems involving Pythagoras' theorem and right-angled triangle trigonometry.

The trigonometry keys, [sin], [cos] and [tan], are multi-tap keys. In the following examples, the angle mode is set prior to the calculation.

Example: Trigonometric ratios (1)

This example shows how to use a calculator to solve a problem involving right-angled triangle trigonometry.

The angle of depression from a drone flying horizontally 100 metres above the water to a buoy at sea is $23°18'$. Find the horizontal distance, x metres, from the drone to the buoy. Give your answer correct to one decimal place.

Teacher Note: It is important to reinforce the following five steps when solving a right-angled triangle trigonometry problem.

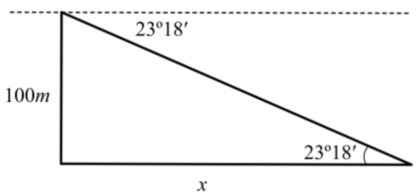
Keystrokes and solution:

The angle mode is **DEG**.

Step (1): Draw a diagram.

Step (2): Label all given and required information where x represents the horizontal distance.

Step (3): From TOA, the required trigonometric ratio is $\tan$.



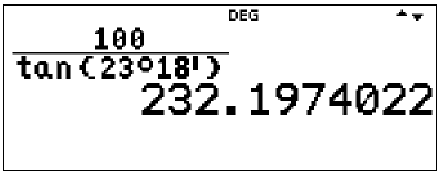
Step (4):

$$\tan 23°18' = \frac{100}{x} \text{ and so } x = \frac{100}{\tan 23°18'}$$

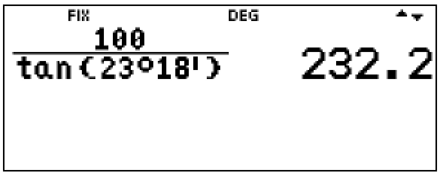
Enter **100** and press [n/d] [tan tan⁻¹] **23** [math] ▶ ▶ [1] **18** [math] ▶ ▶ [2] [)] [enter].

$x = 232.197...$

The horizontal distance is 232.2 metres, correct to one decimal place.



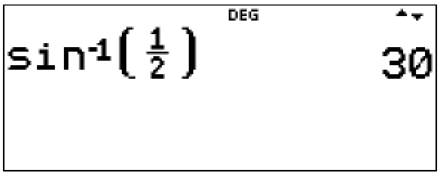
Press [mode] ▼ ▼ ▶ ▶ [enter] to set the decimal notation mode to a one decimal place output.



Given two sides of a right-angled triangle, we can use trigonometric ratios to find unknown angles. For example, if $\sin\theta = \frac{1}{2}$, we can find the angle θ whose sine is equal to $\frac{1}{2}$.

To do this on the TI-30X Plus MathPrint, we use the inverse of sine.

Press [sin sin⁻¹] [sin sin⁻¹] (a multi-tap key) to access $\mathbf{sin^{-1}}$. Enter $\mathbf{\frac{1}{2}}$ and press [)] [enter].



So $\sin^{-1}\frac{1}{2}$ is the 'angle whose sine is $\frac{1}{2}$'.

Inverse trigonometric ratios can be thought of as 'angle finders'.

Example: Trigonometric ratios (2)

This example shows how to use a calculator to find the magnitude of an angle, in degrees and minutes, given a trigonometric ratio for the angle.

Use the TI-30X Plus MathPrint to find the value of θ for $\sin\theta = 0.3798$. Give your answer in degrees and minutes.

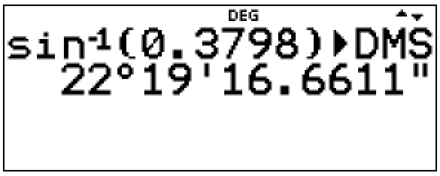
Teacher Note: It is important to reinforce that $\sin^{-1}(0.3798)$ means the angle whose sine is 0.3798.]

Keystrokes and solution:

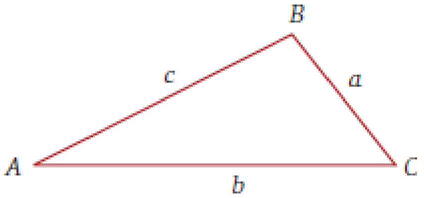
The angle mode is **DEG**.

Press [sin sin⁻¹] [sin sin⁻¹] and enter **0.3798** [)] [math] ▶ ▶ [6] [enter].

In degrees and minutes, $\theta = 22°19'$.



Students are expected to use the sine rule, cosine rule and area of a triangle formula for solving problems where angles are measured in degrees, or degrees and minutes. This can include finding angles and sides involving the ambiguous case of the sine rule.



For a triangle ABC, the sine rule is given by $\dfrac{a}{\sin A} = \dfrac{b}{\sin B} = \dfrac{c}{\sin C}$.

It is used to find unknown lengths and angles when given:

(1) two angles and one side length.

(2) two side lengths and an angle opposite one of the sides.

For a triangle ABC, the cosine rule is given by $a^2 = b^2 + c^2 - 2bc \cos A$.

It is used to find unknown lengths and angles when given:

(1) all three side lengths.

(2) two side lengths and the included angle.

The above formula can be rearranged to find the unknown angle A where $\cos A = \dfrac{b^2 + c^2 - a^2}{2bc}$.

If two sides of a triangle and the included angle are given then $\text{Area} = \dfrac{1}{2} ab \sin C$.

Example: Sine and cosine rule

This example shows how to solve a problem using the cosine rule and the sine rule.

Use the TI-30X Plus MathPrint to find all the unknown angles and side lengths in triangle ABC for which $a = 5$, $b = 4$ and $C = 46°24'$. Give your answer for c correct to two decimal places and your answers for A and B correct to the nearest minute.

Teacher Note: When performing such multi-stage calculations, do not round intermediate answers as this is likely to lead to inaccurate final answers.

Keystrokes and solution:

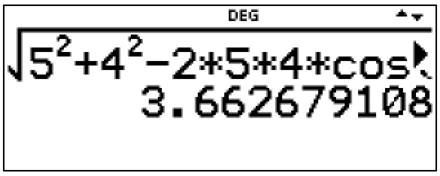
The angle mode is **DEG**.

Using the cosine rule:

$$c = \sqrt{5^2 + 4^2 - 2 \times 5 \times 4 \times \cos 46°24'}$$

Press [2nd] [√] and enter **5** [x²] [+] **4** [x²] [−] **2** [×] **5** [×] **4** [×] [cos] **46** [math] ▶ ▶ [1] **24** [math] ▶ ▶ [2] [)] [enter].

Correct to 2 decimal places, $c = 3.66$.

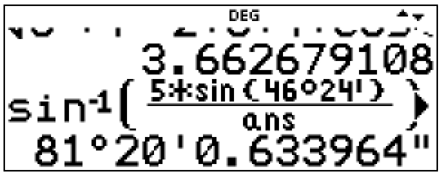


Using the sine rule:

$$\frac{5}{\sin A} = \frac{3.662...}{\sin 46°24'} \Rightarrow \sin A = \frac{5\sin 46°24'}{3.662...}$$

$$A = \sin^{-1}\left(\frac{5\sin 46°24'}{3.662...}\right)$$

Press [sin sin⁻¹] [sin sin⁻¹] [n/d] and enter **5** [×] [sin sin⁻¹] **46** [math] ▶ ▶ [1] **24** [math] ▶ ▶ [2] [)] ▼ [2nd] [answer] ▶ [)] [math] ▶ ▶ [6] [enter].

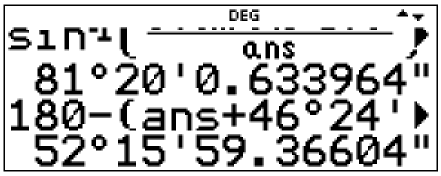


Correct to the nearest minute, A = 81°20'.

Note that careful use of the expression evaluation feature could be used in solving this problem (the pronumerals are a, b, c, A, B, and C).

B = 180° – (81°20' + 46°24')

Enter **180** and press [−] [(] [2nd] [answer] [+] **46** [math] ▶ ▶ [1] **24** [math] ▶ ▶ [2] [)] [math] ▶ ▶ [6] [enter].

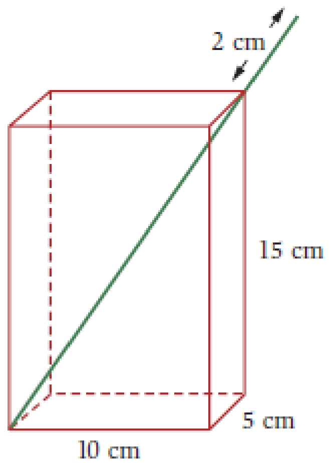


Correct to the nearest minute, B = 52°16'.

Example: Trigonometry and Pythagoras' theorem

This example shows how to use Pythagoras' theorem to solve a three-dimensional problem involving right-angled triangles. In particular, solving a problem involving the lengths of the edges and diagonals of a rectangular prism.

Find the length of a straw which will fit diagonally into a child's fruit juice box (a rectangular prism) and extend out of the box by 2 cm. Give your answer correct to one decimal place.



Teacher Note: When solving three-dimensional problems involving Pythagoras' theorem, it is important to draw carefully labelled diagrams identifying the right-angled triangles, where the theorem can be applied to find unknown lengths.

Keystrokes and solution:

$x^2 = 10^2 + 5^2$

$= 125$

$y^2 = x^2 + 152$

$= 125 + 225$

$= 350$

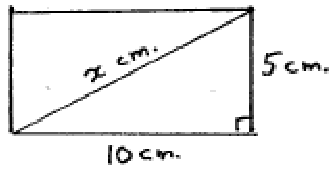
$y = \sqrt{350}$ (cm)

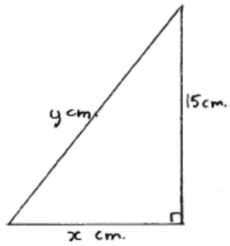
The length of the straw is $(y + 2)$ (cm).

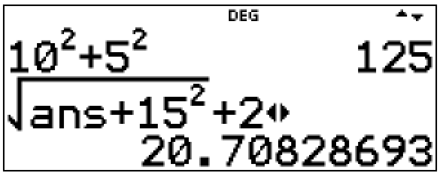
Enter **10** and press [x^2] [+] **5** [x^2] [enter].

Press [2nd] [$\sqrt{\ }$] [2nd] [answer] [+] **15** [x^2] [▶] [+] **2** [◂▸≈] [enter].

Correct to one decimal place, the length of the straw is 20.7 cm.







3.1.2 Radians

Students are expected to understand the unit circle definitions of $\sin\theta$, $\cos\theta$ and $\tan\theta$ and periodicity using degrees. This leads to sketching the trigonometric functions in degrees for $0° \le x \le 360°$.

Example: Unit circle

This example shows how to use a calculator to find exact values of $\tan\theta$ for some first quadrant angles (values of θ). Such an introductory activity could be extended to include other quadrants.

Use the TI-30X Plus MathPrint data editor and list formulas feature to complete the following table of exact values for $\tan\theta$.

θ	0°	15°	30°	45°	60°	75°
$\tan\theta$						

Teacher Note: The approach used in this example can be used to generate the coordinates of points to assist in the first manual sketching of the graphs of $y = \sin x$, $y = \cos x$ and $y = \tan x$. Features of these graphs, such as periodicity and symmetry, can be compared and contrasted. Graphs of the sine, cosine and tangent functions for negative angles can also be investigated.

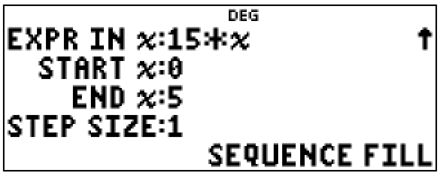
Keystrokes and solution:

The angle mode is **DEG**.

Press [data] [data] [4] to clear all lists.

Press [data] [◀] [3]. Select **L1** and press [enter].

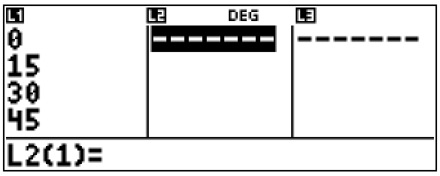
Enter **15** and press [×] [$x\,\frac{yzt}{abcd}$] to paste x, complete the sequence set-up as shown, scroll down to select **SEQUENCE FILL** and press [enter].



These six θ-values should now be displayed in **L1**.

{0, 15, 30, 45, 60, 75}

Press ▶ to scroll across to the top of **L2**.

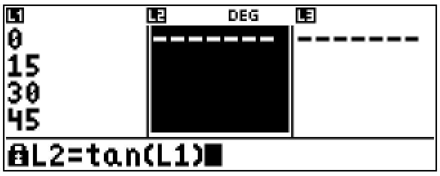


Press data ▶ to select **FORMULA** and press enter.

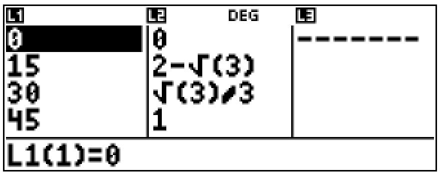
Enter the list formula **tan (L1)** to **L2**.

Press tan/tan⁻¹ and press data enter to paste **L1** into the author line.

Press) enter.



L2 should now display the values of $\tan\theta$ and the table can be completed.



To convert from degrees to radians, multiply by $\dfrac{\pi}{180}$.

Since $180° = \pi^c$, $1° = \dfrac{\pi^c}{180} \approx 0.0175^c$.

Example: Converting between degrees and radians (1)

This example shows how to use a calculator to convert an angle in degrees and minutes to an angle in radians.

Use the TI-30X Plus MathPrint in radian mode to convert $35°25'$ to radians. Give your answer

(a) in terms of π.

(b) correct to four decimal places.

Teacher Note: For part (b), given that $1^c \approx 57°$, students should anticipate an approximate answer of 0.6^c.

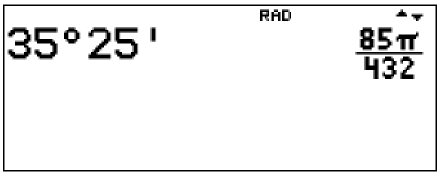
Keystrokes and solution:

The angle mode is **RAD**.

Press mode, select **RADIAN** and press enter.

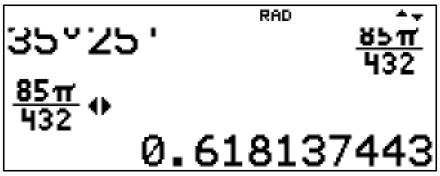
(a) Enter **35** and press math ▶ ▶ 1 **25** math ▶ ▶ 2 enter.

$$35°25' = \frac{85\pi}{432} \text{ (in terms of } \pi\text{)}$$



(b) Press ◀▶≈

$35°25' = 0.6181$ (correct to four decimal places)



To convert from radians to degrees, multiply by $\frac{180°}{\pi}$.

Since $\pi^c = 180°$, $1^c = \frac{180}{\pi} \approx 57°18'$.

Example: Converting between degrees and radians (2)

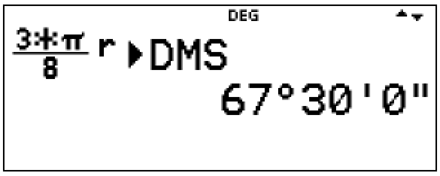
This example shows how to use a calculator to convert an angle in radians to an angle in degrees and minutes.

Use the TI-30X Plus MathPrint in radian mode to convert $\frac{3\pi}{8}$ to degrees and minutes.

Teacher Note: Given that $\frac{3\pi}{8}$ is halfway between $\frac{\pi}{4}$ and $\frac{\pi}{2}$, students should anticipate an answer of 67°30' (halfway between 45° and 90°).

Keystrokes and solution:

$$\frac{3\pi}{8} = \frac{3\pi}{8} \times \frac{180°}{\pi}$$
$$= 67.5°$$
$$= 67°30'$$



The angle mode is **DEG**.

Press [▭/▭] and enter **3.** [×] [π] ⊖ **8** ▶ [math] ▶ ▶ [4] [math] ▶ ▶ [6] [enter].

$$\frac{3\pi}{8} = 67°30'$$

Students are expected to recognise and use the exact values of $\sin\theta$, $\cos\theta$ and $\tan\theta$ in both degrees and radians for θ-values that are integer multiples of $\frac{\pi}{6}$ and $\frac{\pi}{4}$.

Example: Exact values of sin θ, cos θ and tan θ

This example shows how to use a calculator to find exact values of $\sin\theta$ and $\cos\theta$ for θ-values that are integer multiples of $\frac{\pi}{6}$ and $\frac{\pi}{4}$.

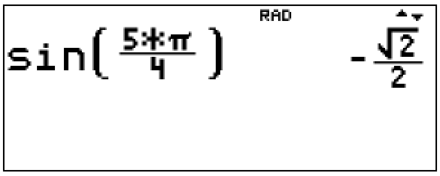
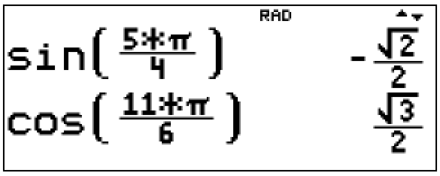
Use the TI-30X Plus MathPrint to find the exact values of

(a) $\sin\frac{5\pi}{4}$.

(b) $\cos\frac{11\pi}{6}$.

Teacher Note: Students need to understand the symmetry properties of the unit circle.

Keystrokes and solution:

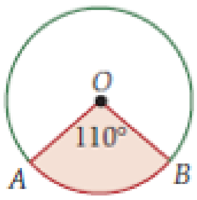
(a) $\sin\frac{5\pi}{4}=\sin\left(\pi+\frac{\pi}{4}\right)=-\sin\frac{\pi}{4}=-\frac{\sqrt{2}}{2}$ The angle mode is **RAD**. For radian mode, press [mode], select **RADIAN** and press [enter]. Press [sin] [n/d] and enter **5** [×] [π] [▾] **4** [▸] [)] [enter]. $\sin\frac{5\pi}{4}=-\frac{\sqrt{2}}{2}$	
(b) $\cos\frac{11\pi}{6}=\cos\left(2\pi-\frac{\pi}{6}\right)=\cos\frac{\pi}{6}=\frac{\sqrt{3}}{2}$ Press [cos] [n/d] and enter **11** [×] [π] [▾] **6** [▸] [)] [enter]. $\cos\frac{11\pi}{6}=\frac{\sqrt{3}}{2}$	

Students are expected to solve problems involving sector areas, arc lengths and combinations of these.

Example: Area of a sector

This example shows how to use a calculator to solve a problem involving the area of a sector.

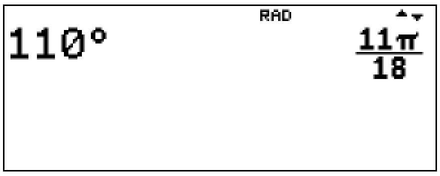
The following diagram shows a sector of area 120 cm^2 which subtends an angle of 110° at the centre of a circle of radius r cm.



Find the radius of the circle. Give your answer correct to one decimal place.

Teacher Note: It is important that students have their TI-30X Plus MathPrint set to radian mode.

Keystrokes and solution:

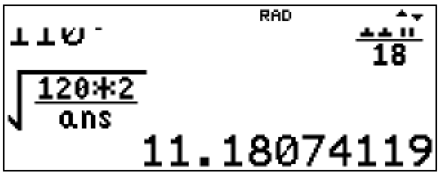
The angle mode is **RAD**. For radian mode, press [mode], select **RADIAN** and press [enter]. Enter **110** and press [math] [▸] [▸] [1] [enter]. $\theta=\frac{11\pi}{18}$	

$$A=\frac{1}{2}r^2\theta$$

$$120=\frac{1}{2}\times r^2\times\frac{11\pi}{18}$$

$$r^2=\frac{120\times 2}{\frac{11\pi}{18}}$$

$$r=\sqrt{\frac{120\times 2}{\frac{11\pi}{18}}}\quad (r>0)$$



Press [2nd] [√] [fraction] **120.** [×] **2** [down] [2nd] [answer] [enter].
Correct to one decimal place, the radius is 11.2 cm.

3.2 Trigonometric functions and identities (MA-T2)

The reciprocal trigonometric functions are defined as follows:

$$\operatorname{cosec}\theta=\frac{1}{\sin\theta},\quad \sin\theta\neq 0$$

$$\sec\theta=\frac{1}{\cos\theta},\quad \cos\theta\neq 0$$

$$\cot\theta=\frac{\cos\theta}{\sin\theta},\quad \sin\theta\neq 0$$

Example: Exact values of cosec θ, sec θ and cot θ

This example shows how to use a calculator to find an exact value of a reciprocal trigonometric function.

Use the TI-30X Plus MathPrint to find the exact value of $\sec\frac{11\pi}{6}$.

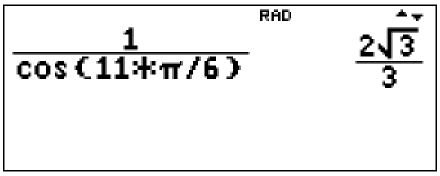
Teacher Note: Students need to understand the relationship between a trigonometric function and its reciprocal.

Keystrokes and solution:

$$\sec\frac{11\pi}{6}=\sec\left(2\pi-\frac{\pi}{6}\right)=\sec\frac{\pi}{6}=\frac{1}{\cos\frac{\pi}{6}}$$

$$=\frac{1}{\frac{\sqrt{3}}{2}}$$

$$=\frac{2\sqrt{3}}{3}$$



The angle mode is **RAD**.

For radian mode, press [mode], select **RADIAN** and press [enter].

Enter **1** and press [fraction] [cos] **11** [×] [π] [÷] **6** [)] [enter].

$$\sec\frac{11\pi}{6}=\frac{2\sqrt{3}}{3}$$

Students are expected to prove and use the Pythagorean identities $\cos^2 x + \sin^2 x = 1$, $1 + \tan^2 x = \sec^2 x$ and $1 + \cot^2 x = \operatorname{cosec}^2 x$.

Example: Identities (1)

This example shows how to use a calculator to numerically verify that $\cos^2 x + \sin^2 x = 1$ for some chosen values of x.

Use the TI-30X Plus MathPrint data editor and list formulas feature to complete the following table of values for the expression $\cos^2 x + \sin^2 x$.

x	0	$\frac{\pi}{6}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{5\pi}{6}$	π
$\cos^2 x + \sin^2 x$							

Teacher Note: Here some first and second quadrant angles are used. Such an activity could be extended to include other quadrant angles and with other identities. Students need to understand the difference between an equation and an identity. Sometimes/Always/Never tasks help achieve this aim.

Keystrokes and solution:

The angle mode is **RAD**.

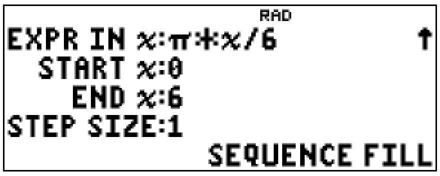
For radian mode, press [mode], select **RADIAN** and press [enter].

Press [data] [data] [4] to clear all lists.

Press [data] [◄] [3]. Select **L1** and press [enter].

Press [π e i] [×] and press [x yzt abcd] to paste x. Press [fraction] and enter **6**.

Complete the sequence set-up as shown, scroll down to select **SEQUENCE FILL** and press [enter].



These seven x-values should now be displayed in **L1**.

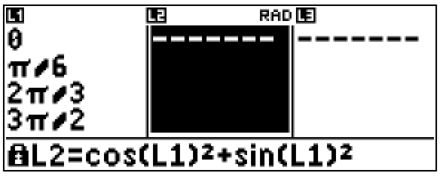
Press [►] to scroll across to the top of **L2**.

Press [data] [►] to select **FORMULA** and press [enter].

Enter the list formula $\cos(\text{L1})^2 + \sin(\text{L1})^2$ to **L2**.

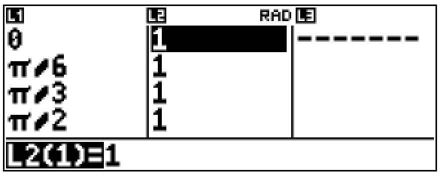
Press [cos cos⁻¹] and press [data] [enter] to paste **L1** into the author line.

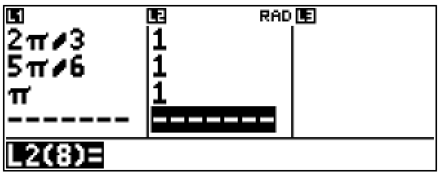
Press [)] [x^2] [+] [sin sin⁻¹] [data] [enter] [)] [x^2] [enter].



L2 should now display the required values and the table can be completed.

For these x-values, $\cos^2 x + \sin^2 x = 1$.





Students are expected to know that $\tan x = \dfrac{\sin x}{\cos x}$ where $\cos x \neq 0$.

Example: Identities (2)

This example shows how to use a calculator to numerically verify that $\tan x = \dfrac{\sin x}{\cos x}$, where $\cos x \neq 0$, for some chosen values of x.

Use the TI-30X Plus MathPrint data editor and list formulas feature to complete the following table of values for $\dfrac{\sin x}{\cos x}$ and $\tan x$.

x	0	$\frac{\pi}{12}$	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{5\pi}{12}$
$\frac{\sin x}{\cos x}$						
$\tan x$						

Teacher Note: The identity $\tan x = \dfrac{\sin x}{\cos x}$ is best shown visually using the properties of the unit circle.

Keystrokes and solution:

The angle mode is **RAD**.

For radian mode, press [mode], select **RADIAN** and press [enter].

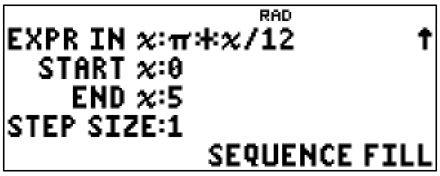
Press [data] [data] [4] to clear all lists.

Press [data] [◄] [3] and select **L1** and press [enter].

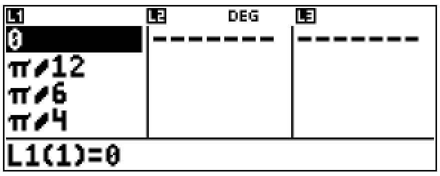
Press [π] [×] and press [x] to paste x.

Press [□/□] and enter 12.

Complete the sequence set-up as shown, scroll down to select **SEQUENCE FILL** and press [enter].



These six x-values should now be displayed in **L1**.

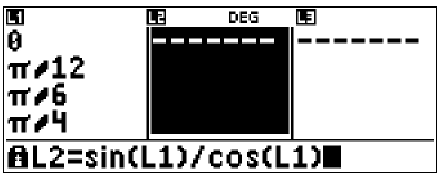


Press [►] to scroll across to the top of **L2**.

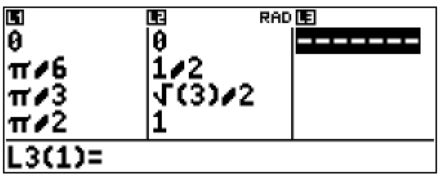
Press [data] [►] to select **FORMULA** and press [enter].

Enter the list formula: $\sin(\text{L1})/\cos(\text{L1})$ to **L2**.

Press [sin] and press [data] [enter] to paste L1 into the author line, press [)] [□/□] [cos] [data] [enter] [)] [enter].



L2 should now display the required values and row two of the table can be completed.

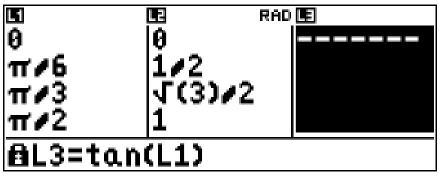


Press ⏵ to scroll across to the top of **L3**.

Press [data] ⏵ to select **FORMULA** and press [enter].

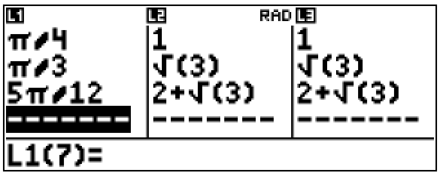
Enter the list formula $\mathbf{tan}(\mathbf{L1})$ to **L3.**

Press [tan] [data] [enter] [)] [enter].



L3 should now display the required values and row three of the table can be completed.

For these x- values, $\tan x = \dfrac{\sin x}{\cos x}$.



For any angle x, $\cos\left(\dfrac{\pi}{2} - x\right) = \sin x$.

Example: Identities for complementary angles

This example shows how to use a calculator to numerically verify that $\cos\left(\dfrac{\pi}{2} - x\right) = \sin x$ for some chosen values of x.

Use the TI-30X Plus MathPrint data editor and list formulas feature to complete the following table of values for $\cos\left(\dfrac{\pi}{2} - x\right)$ and $\sin x$.

x	0	$\dfrac{\pi}{6}$	$\dfrac{\pi}{3}$	$\dfrac{\pi}{2}$	$\dfrac{2\pi}{3}$	$\dfrac{5\pi}{6}$	π
$\cos\left(\dfrac{\pi}{2} - x\right)$							
$\sin x$							

Teacher Note: This identity can be shown either by using a right-angled triangle (acute angles) or by using the unit circle (general angles). This activity could be extended to other complementary identities.

Example, $\cot\left(\dfrac{\pi}{2} - x\right) = \tan x$ where $\tan x$ is defined.

Keystrokes and solution:

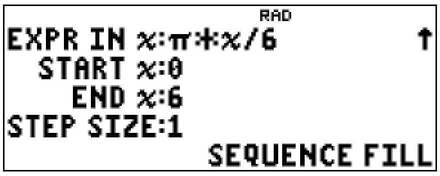
The angle mode is **RAD**.

For radian mode, press [mode], select **RADIAN** and press [enter].

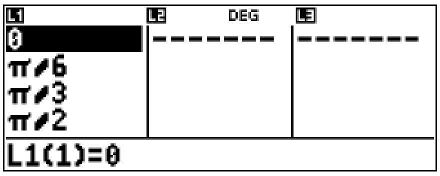
Press [data] [data] [4] to clear all lists, then press [data] ⏴ [3] select **L1** and press [enter].

Press [π] [×] and press [x] to paste x, [÷] and enter $\mathbf{6}$.

Complete the sequence set-up as shown, scroll down to select **SEQUENCE FILL** and press [enter].



These seven x- values should now be displayed in **L1**.

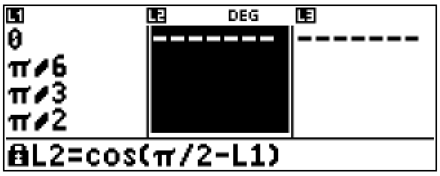


Press [▶] to scroll across to the top of **L2**.

Press [data] [▶] to select **FORMULA** and press [enter].

Enter the list formula $\cos(\pi/2 - \mathrm{L1})$ to **L2**.

Press [cos] [π] [n/d] and enter 2, press [−] and press [data] [enter] to paste $\mathbf{L1}$ into the author line, press [)] [enter].



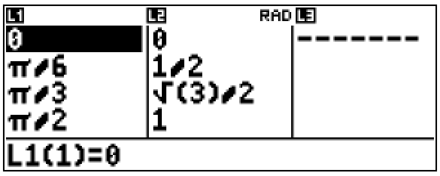
L2 should now display the required values and row two of the table can be completed.

Press [▶] to scroll across to the top of **L3**.

Press [data] [▶] to select **FORMULA** and press [enter].

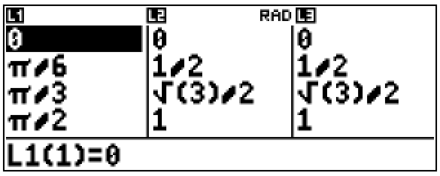
Enter the list formula $\sin(\mathrm{L1})$ to **L3**.

Press [sin] [data] [enter] [)] [enter].



L3 should now display the required values and row three of the table can be completed.

For these x- values, $\cos\left(\frac{\pi}{2} - x\right) = \sin x$.



Students are expected to solve trigonometric equations.

Example: Solving trigonometric equations

This example shows how to use a calculator to help solve a trigonometric equation.

Use the TI-30X Plus MathPrint to solve the equation $\tan x = -3$ for $0° \le x \le 360°$. Give your answers correct to the nearest minute.

Teacher Note: Although $\tan x < 0$, remind students not to use $\tan^{-1}(-3)$.

Keystrokes and solution:

x is in the second or the fourth quadrant.

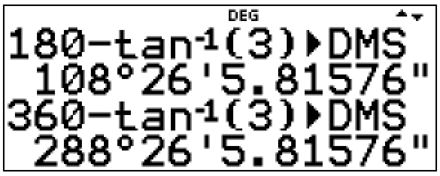
Now $\tan x = 3 \Rightarrow x = \tan^{-1} 3$.

$x = 180° - \tan^{-1} 3$ or $x = 360° - \tan^{-1} 3$

The angle mode is **DEG**.

Enter $\mathbf{180}$ and press [−] [tan] [tan] $\mathbf{3}$ and press [)] [math] [▶] [▶] [6] [enter] [▲] [▲] [enter] [2nd] [◀], edit as shown and press [enter].

$x = 108°26'$ or $x = 288°26'$



3.3 Trigonometric functions and graphs (MA-T3)

Students are expected to study functions of the form $y = kf\left(a\left(x+b\right)\right)+c$ where $f\left(x\right)$ is one of $\sin x$, $\cos x$ or $\tan x$ and a, b, c and k are real numbers. They are expected to use functions of this form to model and/or solve practical problems involving periodic phenomena.

The TI-30X Plus MathPrint data editor and list formulas feature can be used to examine the effect of changing the amplitude, $y = kf\left(x\right)$, the period $y = f\left(ax\right)$, the phase $y = f\left(x+b\right)$ and the vertical shift $y = f\left(x\right)+c$. See page 48 for guidance on how this can be accomplished.

Example: Using trigonometric functions to solve practical problems

This example shows how to use a calculator to help solve a practical problem modelled by a trigonometric function.

The depth, d metres, of a tidal river at a particular point t hours after midnight on Sunday can be modelled by

$d\left(t\right) = 2\cos\frac{\pi t}{6}+3$ where $t \geq 0$.

Find the depth, in metres, of the river at 5 pm on Monday. Give your answer

(a) in exact form.

(b) correct to one decimal place.

Teacher Note: Ensure that students recognise that midnight on Sunday corresponds to the end of Sunday.

Keystrokes and solution:

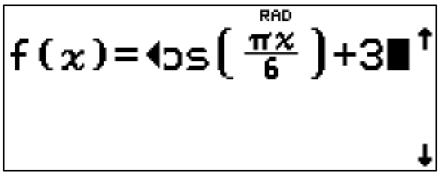
(a) The angle mode is **RAD**.

For radian mode, press [mode], select **RADIAN** and press [enter].

Press [table] [1] to access the function table.

[If required, press [clear].]

Enter $\mathbf{2}$ and press [cos] [fraction] [π] [x] to paste $\boldsymbol{x}$ (t cannot be used), press ⊖ $\mathbf{6}$, ⊙ [)] [+] and enter $\mathbf{3}$, press [enter].

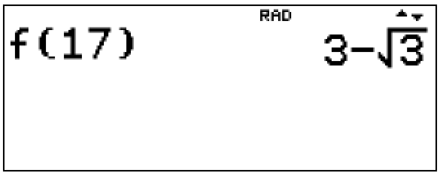


Press [2nd] [quit] to go to the home screen.

Press [table] [2] and enter **17** [)] [enter].

$d\left(17\right) = 3-\sqrt{3}$ (m)

The exact depth of the river at 5 pm on Monday is $\left(3-\sqrt{3}\right)$ metres.



(b) Press [◂▸≈].
Correct to one decimal place, the depth is 1.3 metres.