

INTRODUCTION TO 9100B CALCULATOR

Congratulations, you have just become the proud owner of a new Hewlett-Packard 9100B Calculator. This calculator is a big brother to the successful Hewlett-Packard 9100A. The 9100B however, has several features which more than triple its computing power, these being:

1. A TWO PAGE memory allowing up to 392 program steps or 32 data storage registers.
2. A true SUBROUTINE capability permitting instant access to subroutines from any point in a program.
3. A convenient  $X \leftarrow ( )$  operator allowing rapid data recall to the X register.
4. A STEP PROGRAM "dual display" greatly simplifying program editing and modification.

A detailed explanation of the use of these features is found in the 9100B Operating and Programming Manual (Hewlett-Packard Part No. 09100-90021) supplied with your calculator.

We hope you find the 9100B Calculator and Library a useful tool and guide for your computational work. To better serve you and other 9100 Calculator users, we welcome you to send us program solutions you have written. Please write them up in a format similar to the programs furnished in the Program Library and send them to us. Also send in any comments you might have on the 9100B Calculator and Program Library to our Applications Group. We at Hewlett-Packard look forward to serving you.

Sincerely,

HEWLETT-PACKARD COMPANY

*Dave Cole*  
Dave Cole  
Applications

P.O. Box 301  
Loveland, Colorado 80537



**HP Computer Museum**  
**[www.hpmuseum.net](http://www.hpmuseum.net)**

**For research and education purposes only.**

## INTRODUCTION TO LIBRARY

This Program Library is intended to illustrate practical problem solutions available with the 9100B Calculator. Approximately two thirds of the programs in this library are compatible with the 9100A Calculator. Those programs which are applicable only to the "B" calculator will have a 9100B ONLY above the program number.

Many programs are short enough so that they may be incorporated as subroutines in other programs. Each program consists of a description, equations (with references), examples and a list of the program steps. The programs have been placed in a three-ring binder with classification dividers so that changes, additions and reorganizations can be easily made. Each classification has a corresponding part number and each program within a category is numbered according to the classification part number.

In each Program Library Classification is found a listing of the programs in that section. The first grouping contains 9100A programs (with "A" program numbers). The second grouping contains "B" only programs for that classification. An inspection of the first group program numbers will disclose that certain "A" programs have been removed from the "B" Library. These deleted programs have been replaced by more extensive "B" programs.

### PROGRAM LIBRARY CLASSIFICATIONS

HP Part No.	
09100-70000	Mathematics
09100-70800	Statistics
09100-71000	Electronics
09100-72000	Mechanics
09100-73000	Business
09100-73200	Physics
09100-73700	Thermodynamics
09100-74000	Surveying
09100-74200	Structures
09100-75000	Fluid Mechanics
09100-75200	Life Sciences
09100-75500	Chemical
09100-75800	Secondary Education
09100-76000	Miscellaneous

You are invited to submit programs for inclusion in the Hewlett-Packard KEYBOARD, a periodic publication which contains useful information about the Hewlett-Packard 9100 Calculator systems. Submitted programs having a broad appeal or illustrating ingenious programming techniques will be included in the KEYBOARD with credit.

Please return the Program Library card (in the pocket on the rear cover) indicating the Program Library disciplines in which you are interested.

The following accessories are available:

HP Part No.	
09100-90020	Five Programming Pads
09100-90021	Operating and Programming Manual
09100-90022	9100B Program Library
09100-90024	Diagnostic Card and Envelope
5060-5919	Box of Ten Magnetic Program Cards
4040-0350	Dust Cover
9320-1183	Pull-Out Card (English)
9320-1184	Pull-Out Card (French)
9320-1185	Pull-Out Card (German)
9320-1186	Pull-Out Card (Italian)
9320-1187	Pull-Out Card (Spanish)

## Program Library Usage

To facilitate the use of the 9100B Program Library, brief discussions of:

Manual Program Entry,  
Program Loading from Magnetic Card,  
and 9100B Peripherals

are included here. The Operating and Programming Manual (HP Part No. 09100-90021) covers these topics in greater detail and should be consulted for further information.

### Manual Program Entry

Initially, the program steps must be manually entered into the calculator step-by-step. Then, you may record the program on a magnetic card furnished with your calculator. The use of the magnetic card eliminates repeated manual re-entry. Programs recorded on the magnetic card may be entered instantly, using the ENTER button on the calculator. After entering the program steps into the calculator, it is suggested that you use the sample data to verify test answers. If you do not get the correct answers, it is suggested that you carefully check each program step to see if the program is correctly entered into the appropriate location and/or re-read the user instructions. This may be done by comparing the step location and the code number to the printed program. You can do this very conveniently using the STEP PROGRAM key in the program mode.

### Program Loading

In general, 9100B programs will occupy both the (+) and (-) calculator pages. The most efficient manner to load a 2-page program is to load Side A into the (+) page and Side B into the (-) program page. This can easily be accomplished by placing no END statements on the (+) program page. The END statement may be included on the (-) program page. Load the program as follows:

PRESS: END

ENTER PROGRAM: Side A

(Since there is no END on Side A, the calculator will advance to (-)(0)(0) automatically).

ENTER PROGRAM: Side B

(With or without an END, the calculator will advance to (+)(0)(0) ready for execution).

In the Program Library the above two instructions will be replaced by the single instruction:

ENTER PROGRAM: Side A followed by Side B

To insure that an extraneous END statement does not get recorded on Side A, all unused registers on the (+) page should be filled with CONTINUE's prior to recording.

### 9100B Peripherals

Several peripheral devices are available to complement the 9100B Calculator, these being:

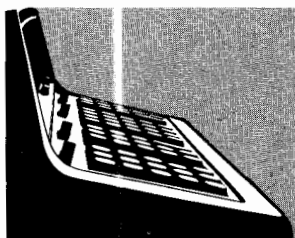
9125A X - Y Plotter  
9120A Printer  
9160A Optical Card Reader  
9150A Display Monitor

The "B" library has been written to simplify the attachment of the 9125A and 9120A to the 9100B. At appropriate input and output points in a program CONTINUE's have been placed for use in calling the printer or plotter. In most cases the plotting programs incorporate plotting Subroutines allowing the user to specify units in terms of inches, or centimeters.

9100B/ 9100A Program Library Cross-Reference

The 9100B Program Library contains several B Only programs which previously were "A" programs. These programs were either multiple pass or storage limited on the 9100A Calculator. After conversion, these programs offer the advantages of being single pass, having ample storage, and in some cases yielding plotted output. The table given below lists these converted programs.

"A" Library Part Number	Program Title	"B" Library Part Number
70015	NUMERICAL INTEGRATION USING SIMPSON'S RULE WHEN $f(x)$ IS KNOWN	70409
70018	CONVOLUTION	70408
70019	4th OR 5th DEGREE POLYNOMIAL ROOTS	70405
70020	INTEGRAL OF THE FORM $F(X) = \int_A^X f(u)du$	70410
70810	WEIBULL DISTRIBUTION PARAMETER CALCULATION FOR FAILURE DATA	70902
70814	MULTIPLE LINEAR REGRESSION	70901
70815	NON-LINEAR REGRESSION-LEAST SQUARES PARABOLA	70903
71002	TCHEBYSHEFF FILTER DESIGN-- FINITE TERMINATIONS	71501
71011	S PARAMETER TO Y PARAMETER CONVERSION	71502
74008	COORDINATE GEOMETRY AND ENCLOSED AREA	74102
74011	TRAVERSE WITH COMPASS RULE ADJUSTMENT OPTION	74101



9100B PROGRAM LISTING

MATHE MATICS 09100-70000

70001 - n!  
 Calculates n! for positive integer n. (n < 70)

70002 - POLYNOMIAL EVALUATION  
 Evaluates polynomials of the form:

$$f(z) = C_n z^n + C_{n-1} z^{n-1} + \dots + C_1 z + C_0$$

for complex  $C_i$ ,  $i=1, \dots, n$  and complex  $z$ .



70003 - NUMERICAL INTEGRATION USING SIMPSON'S ONE-THIRD RULE  
 Uses Simpson's rule to obtain the area under a curve. The equation used is:

$$A = \frac{h}{3} (Y_0 + 4Y_1 + Y_2)$$

70006 - 1st ORDER DIFFERENTIAL EQUATIONS  
 Solves differential equations of the form:

$$y' = f(x, y)$$

70007 - RAISING A NUMBER TO A POWER  
 Solves the equation:

$$Z_3 = Z_1^{Z_2} \text{ where } Z_i = X_i + jY_i \text{ } i = 1, 2, 3$$

70008 - 2nd ORDER DIFFERENTIAL EQUATIONS  
 Solves differential equations of the form:

$$y'' = f(x, y, y')$$

70009 - QUADRATIC EQUATION

Solves  $ax^2 + bx + c = 0$  for the roots.

70010 - FINITE DIFFERENCE INTERPOLATION USING GAUSS'S BACKWARD FORMULA  
 Uses Gauss's backward formula for interpolation in tabular data with equal abscissa spacing.  
 The program fits a cubic equation through the tabular data.

70011 - CUBIC EQUATION

Solves  $x^3 + px^2 + qx + r = 0$  for the real and complex roots.

70013 - FACTORS OF n  
 Gives all factors of an integer n.

70014 - REAL ROOTS OF f(x)  
 Calculates real roots of f(x) by starting from  $x_0$  and incrementing until f(x) changes sign,  
 then converges on the root. f(x) is programmed in by the user.

\* 70016 - SIMULTANEOUS SOLUTION OF TWO EQUATIONS IN TWO UNKNOWNNS  
 The program solves two independent equations of the form:

$$\begin{aligned} ax + by &= e \\ cx + dy &= f \end{aligned}$$

x and y are the unknowns to be found.

MATHEMATICS (CON'T)

70017 -  $n!$  ( $n < 10^{12}$ )

Calculates  $n!$  for positive integer  $n$ .

70021 - POLYNOMIAL EVALUATION ( $1 \leq n \leq 10$ )

Repeatedly evaluates for a given  $x$ , a real polynomial of the form:

$$f(x) = A_n x^n + A_{n-1} x^{n-1} \dots A_1 x + A_0 \text{ for } 1 \leq n \leq 10$$

70022 - 3 X 3 MATRIX INVERSION OR SIMULTANEOUS SOLUTION OF THREE EQUATIONS IN THREE UNKNOWNNS

Solves three linear independent equations in three unknowns simultaneously or inverts a 3 x 3 matrix.

70023 - FOURIER SERIES

Calculates the Fourier Series coefficients that represent a periodic time function  $f(t)$  with period  $T$ . The specific  $f(t)$  is programmed into the calculator by the user.

70024 - GAMMA FUNCTION

Evaluates the gamma function  $\Gamma(\nu)$  for  $0 \leq \nu \leq 10^9$  where  $\Gamma(\nu) = \int_0^{\infty} e^{-t} t^{\nu-1} dt$

70025 - BESSEL FUNCTION

Calculates the value of the Bessel function  $J_n(x)$  of the first kind of integer order  $n$  where

$$J_n(x) = \left(\frac{x}{2}\right)^n \sum_{k=0}^{\infty} \frac{\left(-\frac{x^2}{4}\right)^k}{k! (n+k)!}$$

70401 - HYPERGEOMETRIC SERIES EXPANSION

Given  $a$ ,  $b$ , and  $c$ , this program determines the coefficients of the hypergeometric series  $F(a, b, c; X)$ . This program is useful in solving Gauss's differential equation.

70402 - (3 X 3) MATRIX MULTIPLICATION

Given two (3 x 3) matrices  $A$  and  $B$ , this program determines the product matrix  $C = A \cdot B$ .

70403 - ROOTS OF A 4th DEGREE POLYNOMIAL

This program determines the roots (real and complex) of a 4th degree polynomial of the form

$$X^4 + a_1 X^3 + a_2 X^2 + a_3 X + a_4$$

where  $a_i$  is real.

70404 - NUMERICAL SOLUTION OF TWO FIRST ORDER DIFFERENTIAL EQUATIONS

This program may be used to solve a wide variety of pairs of first order differential equations of the form

$$\frac{dy}{dx} = f(X, Y, Z),$$

$$\frac{dz}{dx} = g(X, Y, Z).$$

70405 - ROOTS OF A 6th DEGREE POLYNOMIAL

The program determines the roots (real and complex) of a 6th degree polynomial of the form

$$X^6 + a_1 X^5 + a_2 X^4 + a_3 X^3 + a_4 X^2 + a_5 X + a_6$$

where  $a_i$  is real.

70406 - CHARACTERISTIC EQUATION OF A (3 X 3) MATRIX AND EIGENVALUE DETERMINATION

Given a (3 x 3) matrix  $A$ , this program computes the characteristic equation

$$\lambda^3 + p \lambda^2 + q \lambda + r = 0$$

and then determines the eigenvalues by using Program 09100-70011 as a Sub-Program.

MATHEMATICS (CON'T)

70407 - SIMULTANEOUS SOLUTION OF FOUR LINEAR EQUATIONS IN FOUR UNKNOWNNS  
 Given a system of four linear equations in four unknowns defined by the matrix equation

$$[A_{ij}] [X_i] = [P_i] ,$$

this program uses Cholewsky's method to determine the  $X_i$ 's.

70408 - CONVOLUTION INTEGRAL WITH PLOT

This program evaluates and plots  $y(t)$ , the convolution of  $e(t)$  and  $h(t)$ . Mathematically

$$y(t) = \int_0^t e(\tau) h(t - \tau) d\tau .$$

70409 - NUMERICAL INTEGRATION USING SIMPSON'S RULE WHEN  $f(x)$  IS KNOWN

The specific  $f(x)$  is programmed into the calculator by the user and is then used by the general solution to evaluate the integral. Execution time is dependent on the number of panels. Note  $f(x)$  should not have any singularities in the integration interval.

70410 - INTEGRAL OF THE FORM:  $F(x) = \int_A^x f(u) du$  WITH PLOT

This program calculates the integral of a known function  $f(u)$  between any lower limit  $A$  and a successively incremented upper limit  $X$ . Simpson's rule is used to perform the integration. A special application of this program is when  $f(u)$  is a probability density function.  $F(x)$  then represents the cumulative distribution function.

70411 - MAX - MIN OF  $Z = Z(X, Y)$

This program determines the approximate range of a function  $Z$  of two independent variables  $X$  and  $Y$  given a range for  $X$  and  $Y$ . This program can be used in conjunction with Program 09100-70412, PLOT OF  $Z = Z(X, Y)$ .

70412 - PLOT OF  $Z = Z(X, Y)$

Given a function  $Z$  of two independent variables  $X$  and  $Y$ , this program creates a three dimensional plot over a prescribed range of  $X$  and  $Y$ .

STATISTICS 09100-70800

70801 - MEAN AND STANDARD DEVIATION

Calculates the mean and standard deviation of  $n$  data points.

70802 - STANDARD DEVIATION AND MEAN OF GROUPED DATA

Calculates the mean and standard deviation of data points of certain frequencies.

70803 - LINEAR REGRESSION

Calculates the best fit of a set of data points to the line  $y = ax + b$ , i.e., the program computes the estimates  $\hat{a}$  and  $\hat{b}$ . It also gives the correlation coefficient  $r$ .

70804 - NORMAL PROBABILITY INTEGRAL

Evaluates the integral under the normal density function.

70805 -  $\chi^2$  - CHI SQUARE DISTRIBUTION

Calculates the integral of the Chi Square distribution from 0 up to a value of  $\chi^2$  for a given number of degrees of freedom.

70806 -  $\chi^2$  - CHI SQUARE EVALUATION EXPECTED VALUES EQUAL ( $E_i = E$ )

Chi square calculation where the expected value of each observation is equal.

70808 -  $\chi^2$  - CHI SQUARE EVALUATION EXPECTED VALUES UNEQUAL ( $E_i \neq E_j$ )

Chi square calculation where the expected values of the observations are not necessarily equal.

70811 - LEAST SQUARES FIT-POWER CURVE

Calculates coefficients fitting data points  $(x_i, y_i)$  to an equation of the form:  $y = ax^b$



STATISTICS (CON'T)

70812 - LEAST SQUARES FIT-EXPONENTIAL

Calculates coefficients fitting data points  $(x_i, y_i)$  to an equation of the form:  $y = ae^{bx}$

70813 - POISSON DENSITY

Calculates the various summations associated with the Poisson density to give a probability based on an input parameter and summation endpoints.

70816 - RANDOM NUMBER GENERATOR

Random numbers (RN) in the range  $0 \leq RN \leq 1$  are calculated; more than 10,000 random numbers may be generated before any previous value is repeated.

70901 - MULTIPLE LINEAR REGRESSIONS

Given a set of data points  $(X_i, Y_i, Z_i)$ , this program determines the coefficients of the linear equation

$$Z = a_0 + a_1X + a_2Y$$

70902 - WEIBULL DISTRIBUTION PARAMETER CALCULATION FOR FAILURE DATA

Calculates the parameters for the Weibull distribution and thus estimates of times to failure percentages may be made.

70903 - NON-LINEAR REGRESSION - LEAST SQUARES PARABOLA

Calculates coefficients fitting data points  $(x_i, y_i)$  to an equation of the form:

$$y = a_0 + a_1x + a_2x^2$$

70904 - NORMAL (GAUSSIAN) CURVE PLOT

Given mean (M) and variance  $\sigma^2$ , this program generates a normal curve given by

$$y = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(X - M)^2}{2\sigma^2}}$$

This program can be used with Program 70905, Histogram Generation.

70905 - HISTOGRAM GENERATION WITH PLOT

This program generates and plots a histogram of ten windows given a set of positive numbers. The mean M and variance  $\sigma^2$  of the data set are computed and stored for use by Program 70904, NORMAL CURVE PLOT.

70906 - HISTOGRAM GENERATION

This program generates a histogram table of ten windows given a data set of positive numbers. In addition it determines the mean M and the variance  $\sigma^2$  of the data set.

70907 - ONE WAY ANALYSIS OF VARIANCE

This program separates the total variance in a table of data into that due to chance and that due to differences between the population means underlying each column of sample data.

70908 - F DISTRIBUTION

This program evaluates the F distribution density function for given values of F,  $V_1$ , and  $V_2$ .

70909 - TWO WAY ANALYSIS OF VARIANCE (m X 4)

This program analyses the total statistical variance in a table of data by separating the total variance into two parts, the variance among rows, and the variance between columns. These variances are then compared to the variance due to random influence.

70910 - TWO WAY ANALYSIS OF VARIANCE WITH REPLICATES

This program analyses the total statistical variance of a table of data by separating the total variance into three parts; the variance among rows, the variance between columns, and the variance due to interaction.

ELECTRONICS 09100-71000

71001 - TCHEBYSHEFF FILTER DESIGN

Calculates component values for Tchebysheff low pass filters with equal terminations.

71003 - BUTTERWORTH FILTER DESIGN

Calculates component values for Butterworth low pass filters between equal terminations.

71004 - MINIMUM LOSS PADS

Calculates resistive minimum loss pad and gives resistor values and loss in dB.

71005 - TCHEBYSHEFF EVALUATION

Used to determine filter order or the frequency response of a particular Tchebysheff filter.

71006 - ATTENUATOR PADS T OR Π

Calculates resistor values for either T or Π pads.

71007 - BAND PASS FILTER DESIGN

Calculates ideal component values and evaluates the frequency response by the image parameter method for a band pass filter.

71008 - STUB MATCHED TRANSMISSION LINE

Calculates the distance from a load to a point where a shorted stub is to be placed and the length of the stub to match a transmission line.

71009 - TRANSMISSION LINE

Calculates the impedance at any point on a transmission line either toward the generator or toward the load, the voltage reflection (magnitude and phase) and the VSWR on the line.

71010 - WYE → DELTA AND/OR DELTA → WYE CONVERSION

Transforms impedances wired in delta configuration to the equivalent wye configuration and vice-versa. Loop and nodal analyses are used to perform the transformations.

71501 - TCHEBYSHEFF FILTER DESIGN - FINITE TERMINATIONS

Calculates component values for Tchebysheff low pass filters with finite terminations (equal or unequal).

71502 - S PARAMETER TO Y PARAMETER CONVERSION

Converts S parameters for linear (active or passive) circuits to Y parameters.

71503 - FREQUENCY RESPONSE FROM POLES AND ZEROES WITH PLOT

Given the zeroes and poles of a complex function  $f(s)$ , the magnitude and phase response is computed over a specified frequency range. The program can consider any combination of six poles and zeroes of the form  $r_i = \dots + jw$ .

MECHANICS 09100-72000

72002 - TRANSCENDENTAL EQUATION (ARC INVOLUTE IN GEAR DESIGN)

Solves for the angle  $\phi$  in radians in the following expression

$$\text{INV}(\phi) = \text{TAN} \phi - \phi$$

where the INV ( $\phi$ ) is given.  $1 \times 10^{-17} < \phi < 1 \times 10^6$  ( $\phi$  is in radians).

72003 - SPRING DESIGN - COMPRESSION AND EXTENSION SPRINGS

This program calculates one of three variables (d - diameter of wire, N - number of turns of wire, and D - mean coil diameter), the remaining two being set, and calculates the maximum allowable stress. Other inputs are set to predetermined values.

72004 - STRESS AND STRAIN FROM A RECTANGULAR ROSETTE

Calculates the principal strains and stresses given rectangular rosette and strain gauge inputs.

72501 - PROPERTIES OF AREAS

This program determines the properties of any area which can be approximated by a set of rectangles. The properties determined are:

1. Area
2. Moments of inertia
3. Distances from axes to the centroid
4. Products of inertia about the centroid

CHEMICAL (CON'T)

75505 - MOLECULAR WEIGHT BY VPO

Calculates molecular weight for an unknown based on a series of vapor pressure osmometer (VPO) readings at various dilutions by extrapolating a least squares curve fit to infinite dilution.

75506 - MEMBRANE OSMOMETER

Determines the number-average molecular weight by extrapolating a least squares curve fit to infinite dilution.

SECONDARY EDUCATION 09100-75800

75802 - PRIME NUMBERS

Calculates all prime numbers between any two numbers.

75901 - CONIC SECTION DETERMINATION WITH PLOT

Given the generating angle of a cone,  $\beta$ , and the intersection angle with a plane,  $\alpha$ , this program determines and plots the conic section.

MISCELLANEOUS 09100-76000

76003 - NAVIGATIONAL COURSE CALCULATION

Calculates course settings for one or more adjoining legs of a proposed journey, the length of each leg, and the total distance covered on completion of the journey.

76004 - CIRCLE DETERMINED BY THREE POINTS

Calculates the radius and center point (in rectangular coordinates) of the circle defined by three given points.

76005 - AREA OF A RECTILINEAR SURFACE POLYGON

Calculates the area of any rectilinear polygon given the rectangular coordinates of the vertices.

76501 - DIAGNOSTIC (EXERCISER)

The program exercises each calculator operation and memory location with the exception of the FMT, PRINT, and error conditions.