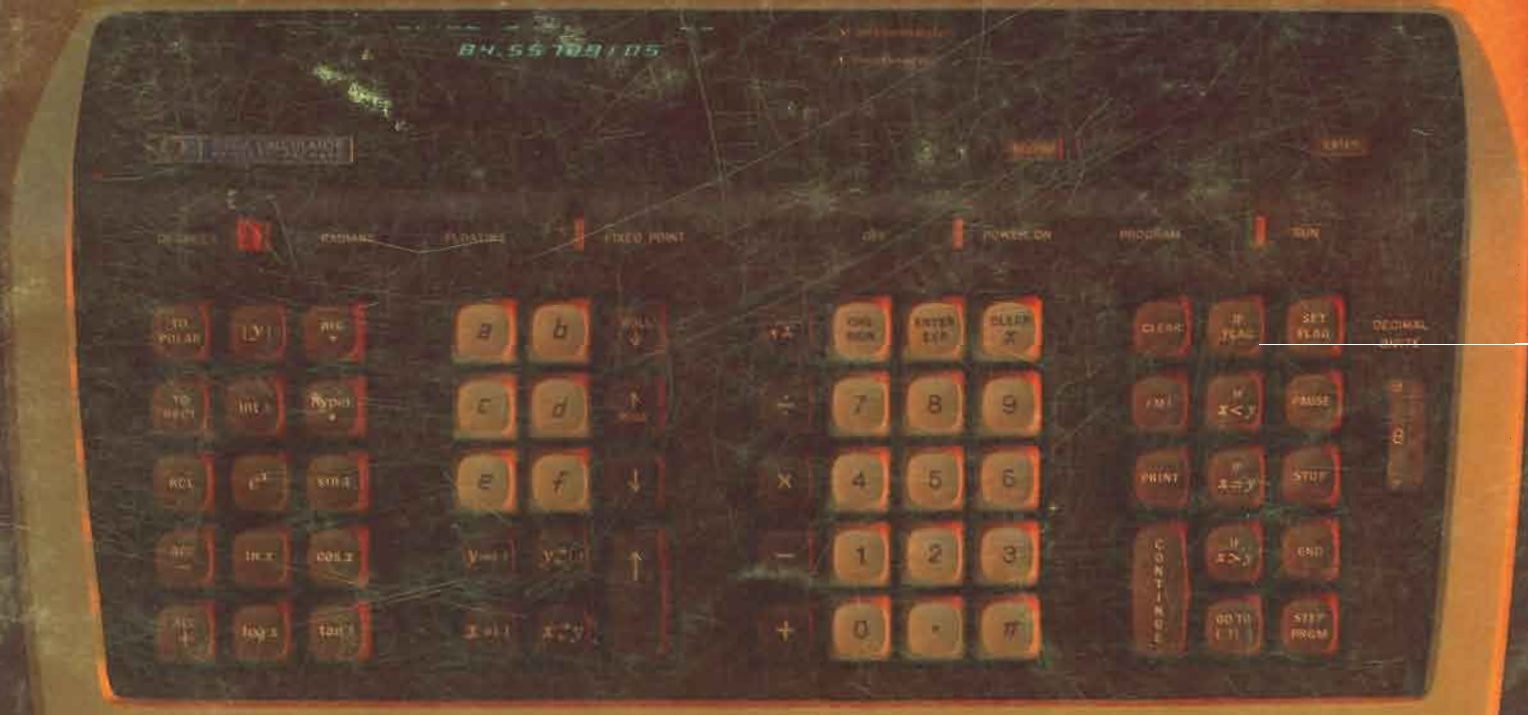
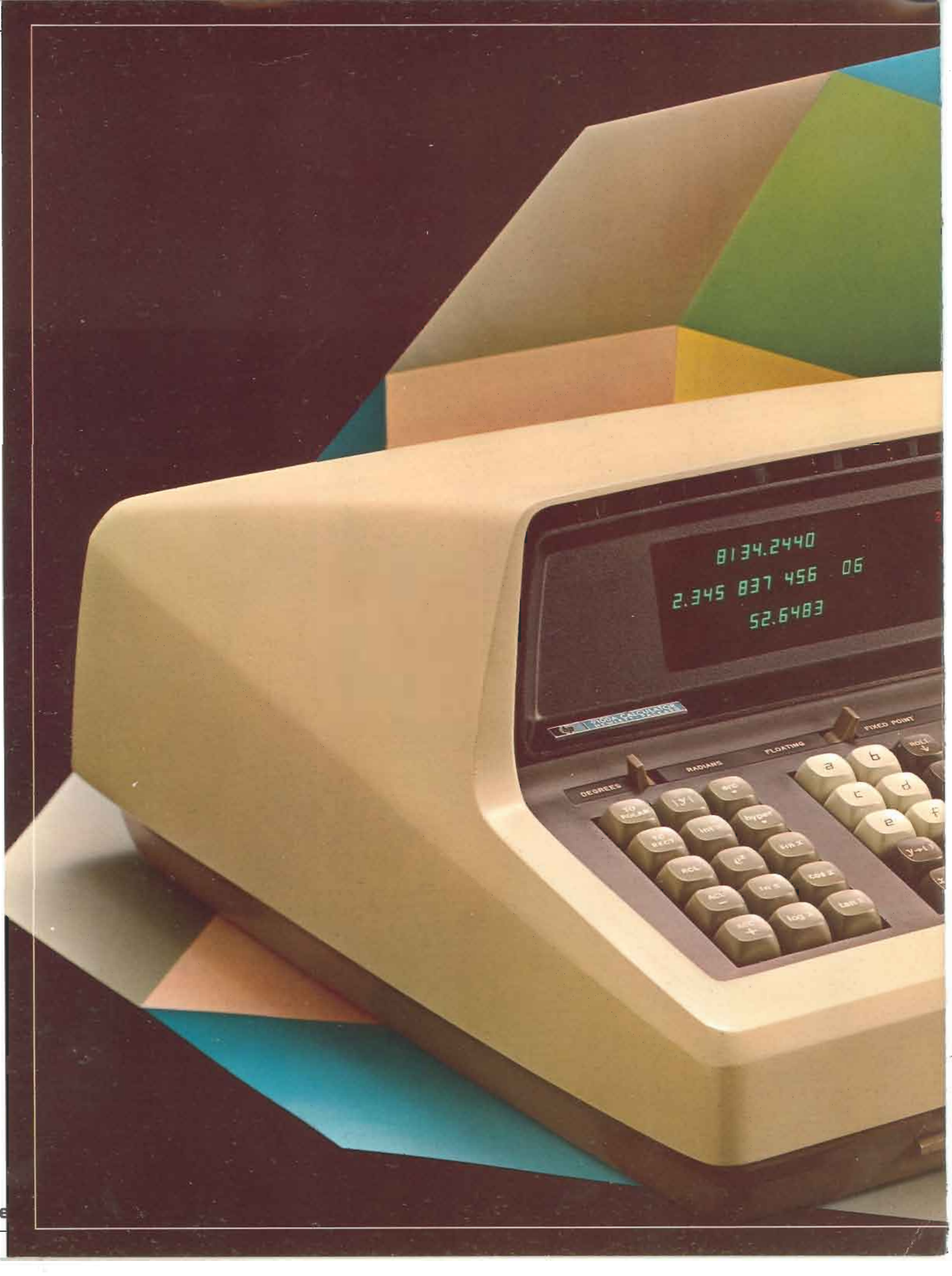
hp 9100A Calculator



HEWLETT hp PACKARD

Expand Your Time for Creative Thinking!


8134.2440
2.345 837 456 06
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DESIGNED FOR ENGINEERS
FIXED POINT
FLOATING
RADIANS
DEGREES


OFF
POWER ON
PROGRAM
RUN
SIGNAL-
DIGITS

Free yourself from the tedium of engineering and scientific calculations. Concentrate on results, not how to get them. Focus your efforts on ideas. Put answers just a touch away with the new hp computing calculator!

Oriented to the engineering and scientific professions, the new hp 9100A Calculator contains all of the log, trig, and mathematical functions found on complex engineering slide rules—and more! These functions are called up and calculated in milliseconds at the press of a single key.

Extensive program capabilities include conditional qualifiers, giving the hp 9100A the ability to make looping and branching decisions normally found only on large sophisticated computers. The hp computing calculator can be programmed by the operator from the keyboard or by a magnetic program card. Programming is easy, and you can converse with the hp 9100A directly—without learning a special

TOUCH AND SEE

language. Operation is so simple that non-technical personnel can perform complex calculations with a minimum of training.

Use the easily accessible 9100A with its program capability for solving complex, every-day problems. Use it as an essential companion instrument for your large computer or your time-share facility. Use the 9100A to "de-bug" and verify complex algorithms for large computers. Save your large computer for data reduction requiring large storage capacity. Use the 9100A to expand your creative time.

Creative time is difficult to value in dollars and cents. However, a value **can** be placed on man-hours and computer time. Priced at $4900, the hp computing calculator can easily pay for itself in a matter of months, in savings of manhours and computer time alone.

This new desk-top calculator cuts the high cost of creativity—truly allows you more time for creative thinking—like having a computer sitting on the corner of your desk!

New hp Programmable Calculator Puts Answers At Your Fingertips

One Look

and You Know the hp 9100A is More– Far More– than a Calculator

We call the new hp 9100A a calculator – but you can see it is infinitely more! It has an exceptionally broad dynamic range from 10^{-98} to 10^{99} with resolution to 10 significant digits. It has single-key log and trig functions, and forward and inverse circular and hyperbolic functions. With its 16 storage registers, its 196-step program memory and the ability to make branching and looping decisions – all at computer speed – the 9100A is more than a calculator – it's really a desk-top computer!

The rugged, all-solid-state circuitry is completely contained in the typewriter-size 9100A. It is easily portable. It is quieter than your watch – because it has no mechanical movements or fans.

The dynamic range of 10^{-98} to 10^{99} is two to three times greater than most large-scale computers. You can work with very small and very large numbers simultaneously.

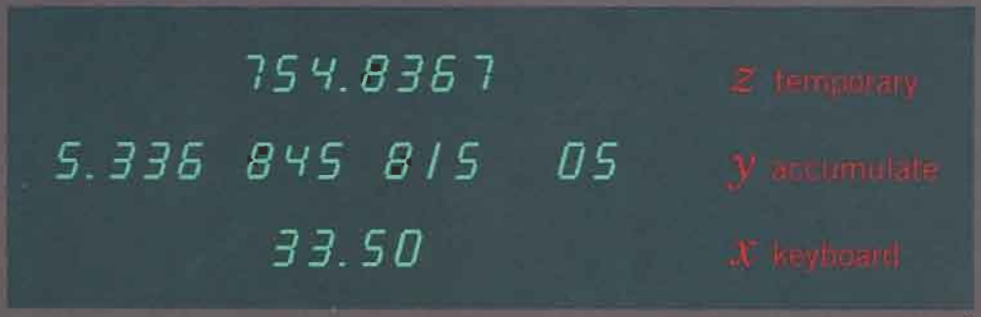
Speed and broad range of the 9100A result from a unique combination of memory systems. The read-only memory provides trig functions in all four quadrants, and all log functions as fixed sub-routines. The magnetic core memory accommodates 196 program steps which can be commands, or numeric constants in your equation. Programs can be recorded on a wallet-size magnetic program card.

The 9100A allows you to enter and/or display your entries in fixed or floating decimal point notation. The 9100A also provides degree or radian modes for performing trigonometric operations.

The hp 9100A is called a calculator – but you can see it is capable of performing many functions previously possible only with a large, expensive computer system!


RECORD
ENTER
OFF
POWER ON
PROGRAM
RUN
$\sqrt{x}$
CHG SIGN
ENTER EXP
CLEAR x
÷
7
8
9
×
4
5
6
−
1
2
3
+
0
.
π
CLEAR
IF FLAG
SET FLAG
FMT
IF $x<y$
PAUSE
PRINT
IF $x=y$
STOP
CONTINUE
IF $x>y$
END
GO TO ( ) ( )
STEP PRGM
DECIMAL DIGITS
9
8
7

Easy-to-read Display

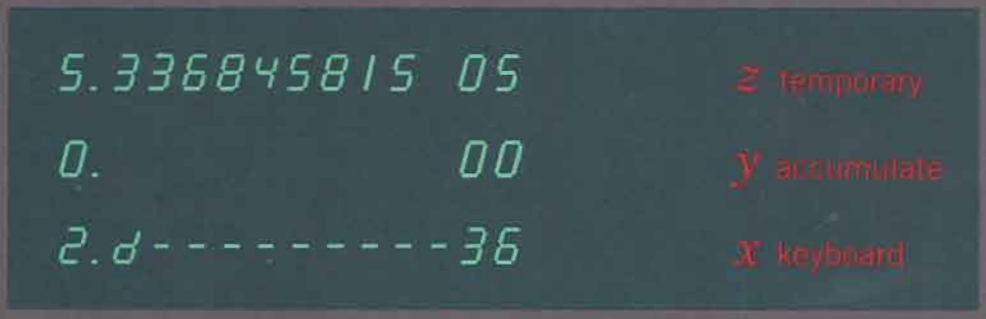


The easy-to-read cathode ray tube display shows three registers—X, Y and Z so you can clearly see all mathematical operations. The X and Y registers are working registers and the Z is a visible storage register.

All calculations are performed internally to 12 significant digits. Up to 10 of these significant digits can be displayed on the monitor. Insignificant zeros are automatically blanked and decimals are automatically positioned.

In the **FIXED** mode, values are automatically rounded—depending on the number of decimal places you have selected with the decimal wheel at the right of the keyboard. The 9100A also automatically switches to floating decimal display, as shown in the Y register above, when you overflow a register in **FIXED** mode. You do not have to rescale your problem and start from the beginning to get the correct answer.

When the 9100A is set in the **FLOATING** mode, the display shows up to ten significant digits, in easy-to-read groups of three, and the exponent of 10.



You can step through and check each program step using the **STEP PRGM** key when the 9100A is set in **PROGRAM** mode. The program step number is shown at the left of the X register. The program command number—signifying the function to be performed—is shown at the right. (36, for example, is the command to the calculator to multiply.)

The light, at the left of the display, lights red when "illegal" operations, such as the square root of a negative number, are attempted.

AND SEE

Entry and Arithmetic Operations

This section of the 9100A keyboard provides the basic calculator functions for entering numbers and performing the basic arithmetic operations.

A number may be entered in either fixed or floating decimal point notation, regardless of the setting of the **FIXED/FLOATING** switch. To enter a number in fixed notation, press the appropriate numbers and decimal point in the proper sequence. To enter a number with floating decimal point notation, press the keys to enter your significant digits, then the **ENTER EXP** key and your exponent—1 and 8, for example, to indicate 10^{18}. The **CHG SIGN** key changes the sign of your exponent.

The **CLEAR** x key erases the entry you have made in the X register. Use it to correct entries. The π key displays up to 10 digits of the value of pi in the X register. The $\sqrt{x}$ key is used to find the square root of the number you have entered in the X register.

EXAMPLE: To find the square root of 7.34:

Press: [7] [•] [3] [4] [$\sqrt{x}$]

Answer is displayed in X.

Positioning and Storage

Arithmetic operations involve two numbers and require moving the number to be operated on to the Y register. To do this, enter the number in the X register, then press the ↑ key. The number then appears in the Y register. Enter the operating number in the X register, then press the arithmetic function you wish calculated. The result appears in the Y register.

You can store the contents of X and Y for later recall, using the $x\rightarrow$( ) or $y\rightarrow$( ) keys followed by any one of the six alphabetical or ten numeric keys. Stored numbers can be easily recalled by pressing an alpha key or $y\rightleftarrows$( ) and a number key. The contents of X and Y remain in display after they have been duplicated in storage. The other positioning keys in this keyboard section allow repositioning numbers to save program steps.

AND SEE

Coordinate Conversions, Extended Trig and Log Functions

The hp 9100A provides complete capabilities for complex or vector arithmetic. Pressing the **TO POLAR** key performs the following operations on the X and Y entries: $R = \sqrt{x^2 + y^2}$ with R appearing in the X register, and $\theta = \tan^{-1}\frac{y}{x}$ with θ expressed in the proper quadrant appearing in the Y register.

Pressing **TO RECT** (to rectangular) with R in the X register and θ in the Y register displays $R \sin \theta$ in the Y register and $R \cos \theta$ in the X register.

The accumulate positive and accumulate negative keys give you vector addition and subtraction. Pressing **ACC+** key adds the contents of the X and Y registers to existing numbers in storage registers f and e, respectively. The **ACC–** key subtracts the values of X and Y from the numbers stored in f and e. The **RCL** (vector recall) key transfers the accumulated contents of f and e to the X and Y registers.

Extended trig capability is contained in five keys – **arc ▼**, **hyper ▼**, **sin x**, **cos x** and **tan x**. The sin, cos and tan keys cover all four quadrants. The **arc ▼** key is the prefix to calculate inverse trigonometric or hyperbolic functions. The **hyper ▼** key is the prefix to calculate hyperbolic functions.

Log functions are covered by **e^x**, **ln x** and **log x**. The **int x** key truncates x to form an integer. The **$|y|$** key gives the absolute value of y.

Each of these transcendental functions is possible with the press of a single key – because of the exclusive hp read-only memory.

Programming

Programming the 9100A is as simple as writing your equation in sequential steps. Sample programs are furnished with the calculator to help you design your programs. A handy reminder of program capabilities is contained on a pull-out card located below the keyboard.

Branching and looping instructions can be easily inserted in your program by using the qualifying **IF** keys—which give you capabilities usually found only on large computers. Changes in your program are simple to make, too. You may address and correct an individual step. You do not have to re-enter the entire program!

In **RUN** mode, each depression of **STEP PRGM** key executes one program step at a time and the results are shown on the monitor. In **PROGRAM** mode, the **STEP PRGM** key can be used to check and "de-bug" your program. Each time the key is pressed, the program address and the command (instruction) number are shown in the X register.

The **CLEAR** key clears the display and accumulate-registers e and f. **CONTINUE** starts program execution.

FMT (format) and **PRINT** keys will be used with peripherals such as printer-readout and X-Y plotter.

AND SEE

Magnetic Programming Card

Once you have a program in the 9100A calculator, you can make a permanent record of the program on a wallet-size magnetic programming card. Simply insert the card in the slot, press **RECORD** and the calculator records everything in its memory on the card.

Two complete 196-step programs can be entered on each magnetic program card. If your program consists of more than 196 steps, program cards can be cascaded.

Re-entering the program is equally as easy and fast. Insert the card in the slot and press **ENTER**. The information on the card is instantly entered in the calculator memory.

Hewlett-Packard has prepared a library of more than a hundred programs to aid you in your problem-solving. A copy of this library is furnished with the calculator, and as the library is expanded, an index to new and modified programs will be furnished to 9100A owners.

Peripheral Equipment

Peripheral equipment is being developed to make use of the input/output capabilities of the 9100A Calculator. The first is a silent, electrostatic printer which mounts on the top of the calculator. An X-Y plotter interface and a general purpose input/output interface are also being developed.

TOUCH AND SEE Complex Every-Day Problems Solved in Seconds

Here are examples of the engineering/scientific problems you and the hp 9100A Calculator can solve—rapidly and simply. These examples are taken from the program library—which also includes roots of a fifth degree polynomial, solution to three simultaneous equations, Bessel functions, Fourier analysis, solution of incomplete elliptic integrals of the first and second kinds, Fresnel integrals, real and complex polynomial evaluation.

Regression Analysis

Analytical researchers, process engineers and personnel in other scientific disciplines are regularly confronted with the problem of describing a set of experimentally obtained X-Y points. The method of least squares—squaring the deviations, then minimizing this sum of squares—is commonly used to determine the straight line that best fits a set of X-Y points. The general form of the straight line is:

$$y = mx + b$$

where: m is the slope of the line and b is the y intercept.

The method of least squares also yields the coefficient of r:

$$r = \frac{n\sum x_i y_i - \left(\sum x_i\right)\left(\sum y_i\right)}{\sqrt{\left[n\sum x_i^2 - \left(\sum x_i\right)^2\right]\left[n\sum y_i^2 - \left(\sum y_i\right)^2\right]}}$$

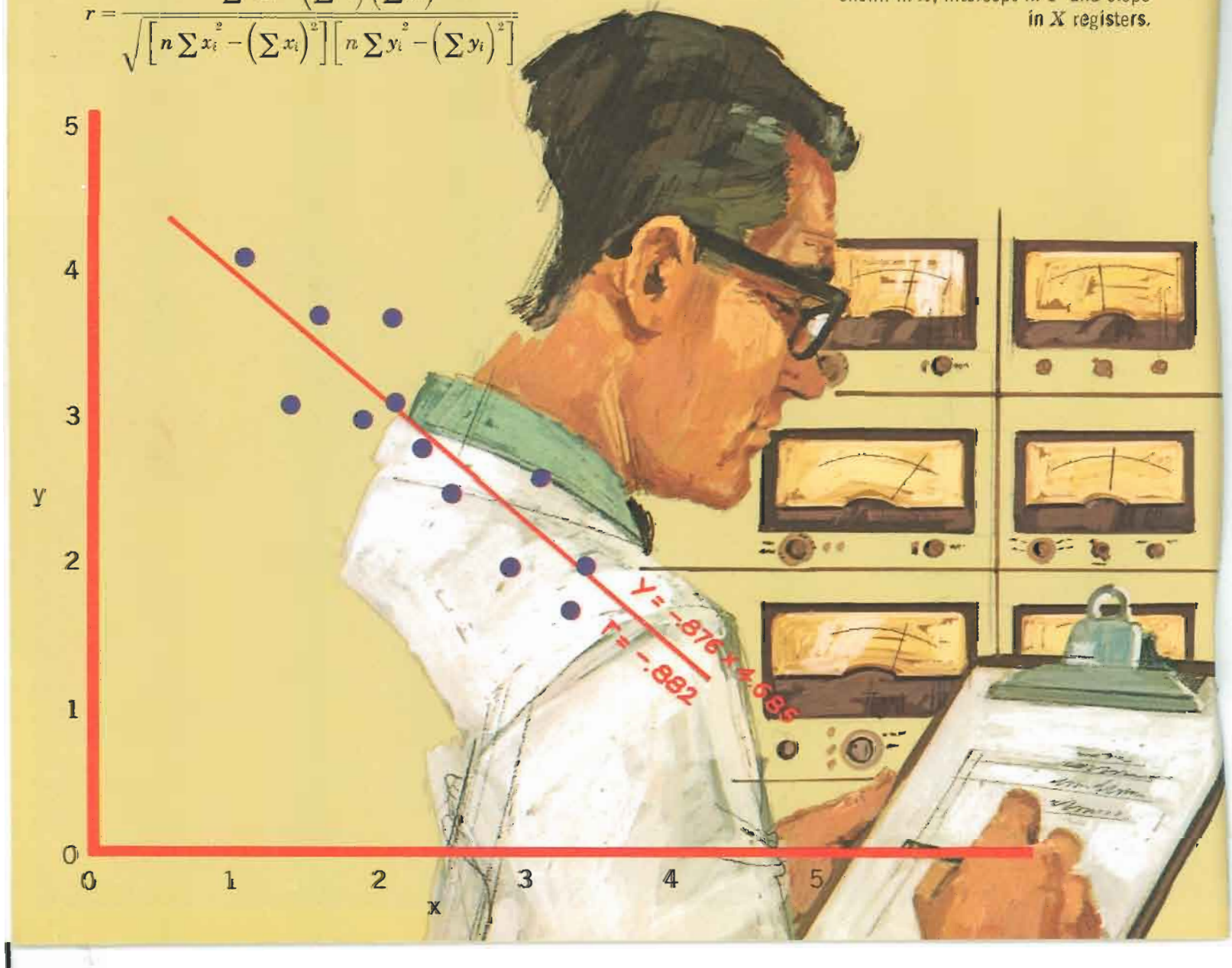
For perfect correlation, r equals ± 1. If r yields a value near zero, there is almost no linear correlation between the variables.

We can also calculate the intercept b and the slope m:

$$b = \bar{y} - m\bar{x} \text{ where } \bar{y} = \frac{\sum y_i}{n} \text{ and } \bar{x} = \frac{\sum x_i}{n}$$

$$m = \frac{\sum\left(x_i - \bar{x}\right)\left(y_i - \bar{y}\right)}{\sum\left(x_i - \bar{x}\right)^2}$$

After entry of an arbitrary number of data points, the 9100A gives a display on the monitor in milliseconds. The correlation coefficient is shown in Z, intercept in Y and slope in X registers.



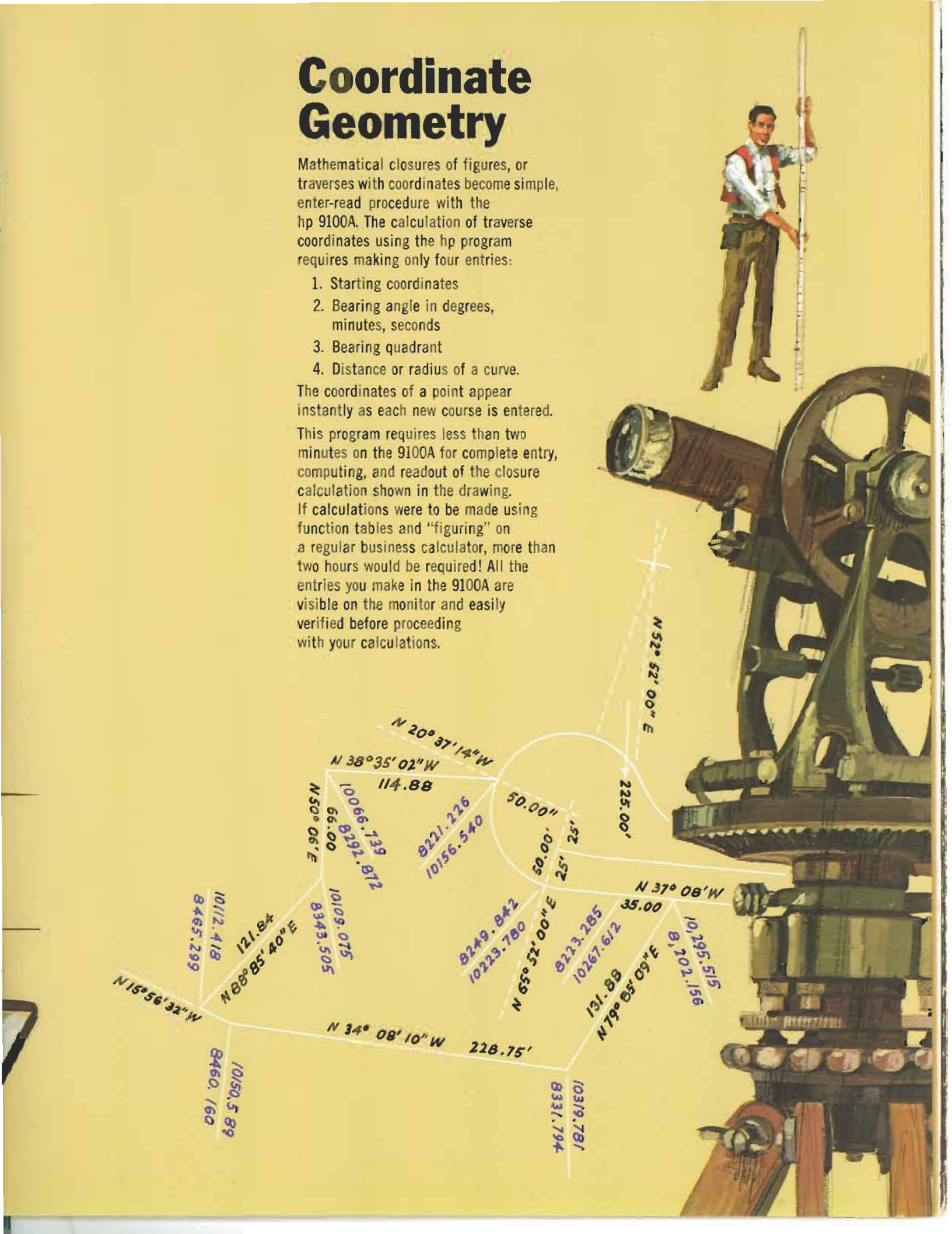
Coordinate Geometry

Mathematical closures of figures, or traverses with coordinates become simple, enter-read procedure with the hp 9100A. The calculation of traverse coordinates using the hp program requires making only four entries:

1. Starting coordinates
2. Bearing angle in degrees, minutes, seconds
3. Bearing quadrant
4. Distance or radius of a curve.

The coordinates of a point appear instantly as each new course is entered.

This program requires less than two minutes on the 9100A for complete entry, computing, and readout of the closure calculation shown in the drawing. If calculations were to be made using function tables and "figuring" on a regular business calculator, more than two hours would be required! All the entries you make in the 9100A are visible on the monitor and easily verified before proceeding with your calculations.



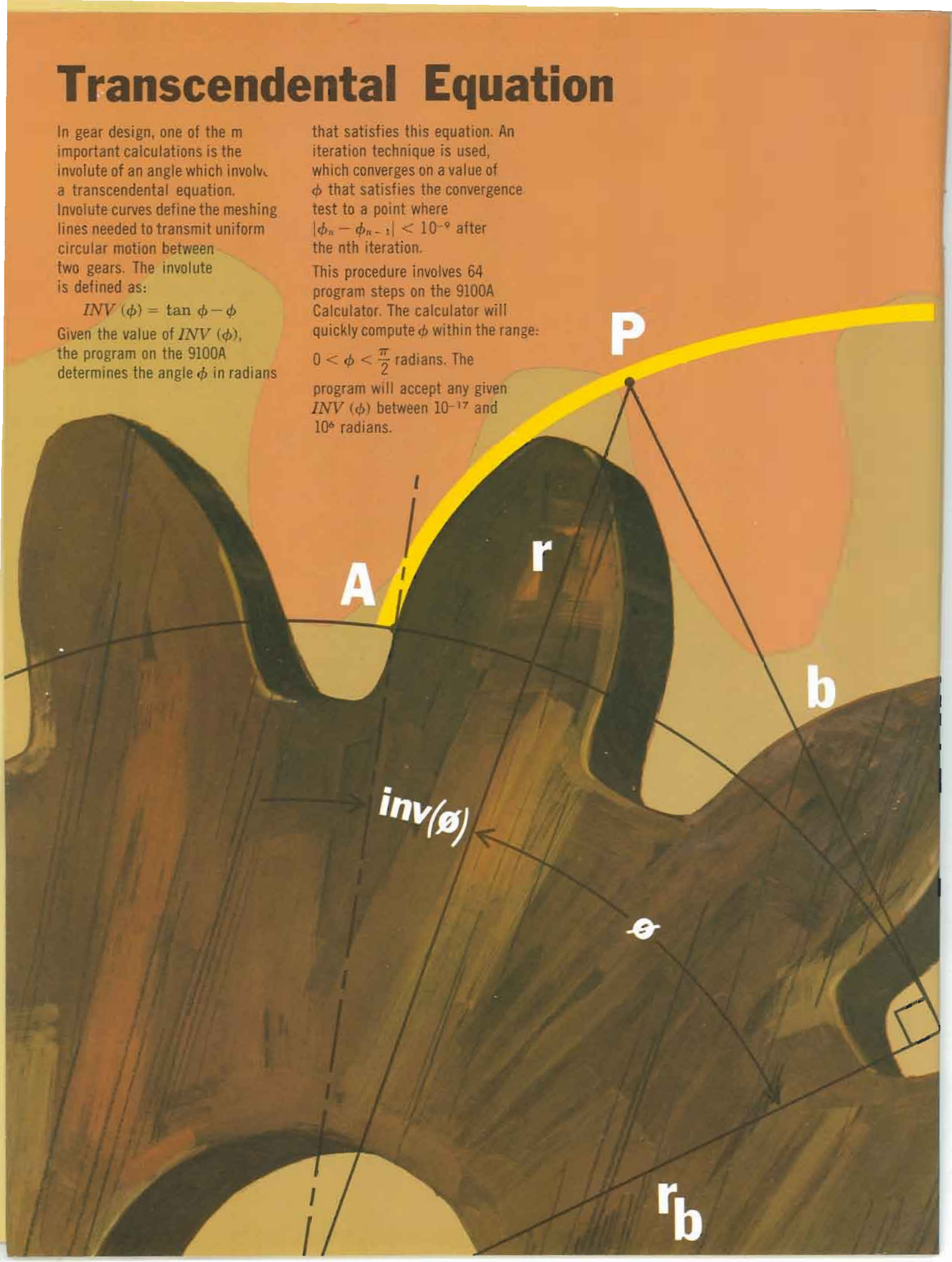
Transcendental Equation

In gear design, one of the m important calculations is the involute of an angle which involv. a transcendental equation. Involute curves define the meshing lines needed to transmit uniform circular motion between two gears. The involute is defined as:

$$INV\ (\phi) = \tan \phi - \phi$$

Given the value of $INV\ (\phi)$, the program on the 9100A determines the angle ϕ in radians that satisfies this equation. An iteration technique is used, which converges on a value of ϕ that satisfies the convergence test to a point where $|\phi_n - \phi_{n-1}| < 10^{-9}$ after the nth iteration.

This procedure involves 64 program steps on the 9100A Calculator. The calculator will quickly compute ϕ within the range: $0 < \phi < \frac{\pi}{2}$ radians. The program will accept any given $INV\ (\phi)$ between 10^{-17} and 10^{6} radians.



Numerical Integration

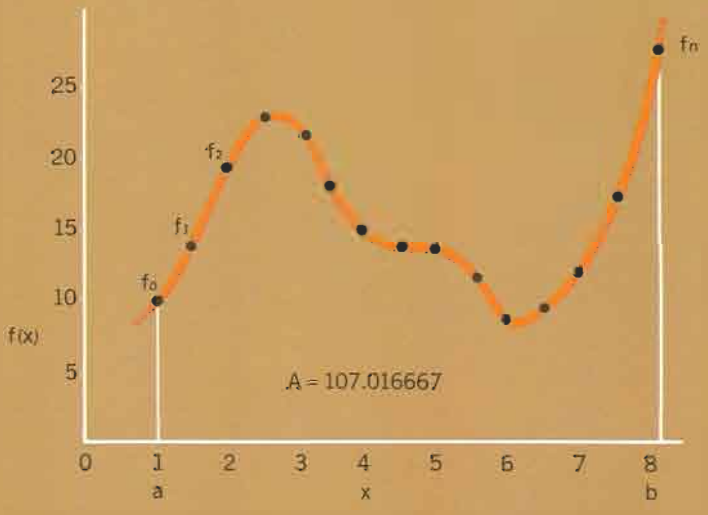
Frequently, the real world of science and engineering cannot be described by a mathematical equation. This quandary occurs when you must determine the area beneath a curve derived from experimental data. Numerical integration of the curve, however, does provide an accurate solution. With the speed of the hp 9100A, integration now becomes a routine solution with answers available as fast as you can enter the data.

The equation in this program is based on Simpson's one-third rule to perform the integration:

$$\int_a^b f(x)\,dx = \frac{h}{3}\,(f_0 + 4f_1 + 2f_2 + 4f_3 + \cdots f_n) + \epsilon(h^4)$$

where: ϵ is an error term.

This procedure involves 65 program steps. The 9100A solves for the area A within milliseconds after each data point is entered. Other integration techniques, employing the Euler/Maclaurin series, can also be programmed.

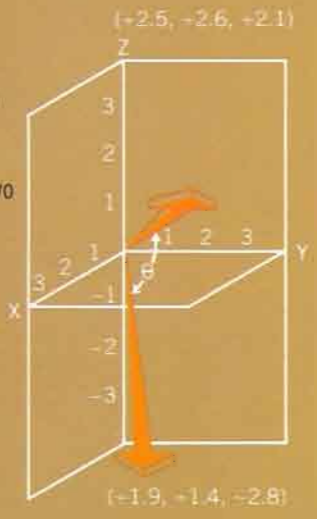


Three Dimensional Vectors

Frequently in solving structural or electrical problems, it is necessary to work with three-dimensional vectors. The program designed for use on the 9100A Calculator allows you to find the angle θ between two vectors defined in three-dimensional space.

In the illustration, given the values of $X_1 = +2.5$, $Y_1 = +2.6$, and $Z_1 = +2.1$, and $X_2 = +1.9$, $Y_2 = +1.4$, $Z_2 = -2.8$, the angle θ is calculated to be 80.547872°, or (with the mode switch to *RADIANS*) 1.405826 radians.

Programs are also provided for solving other three-dimensional vector problems, such as cross product or dot product.



Network Analysis

Network analyses are easily accomplished using the logarithmic and hyperbolic capabilities of the 9100A.

Given the image impedance level and the desired bandpass of a filter, the program calculates the ideal component values. If values of closest commercially available components are substituted for these ideal values, the program then calculates the frequency response of the proposed filter. This error analysis can also include the effects of component tolerances.

The program makes use of the hyperbolic function capabilities of the 9100A to solve the following equations for the evaluation of frequency response:

$$\frac{X_A}{4X_B} = \frac{(\omega^2 C_A L_A - 1)\,(1 - \omega^2 C_B L_B)}{4\omega^2 C_A L_B}$$

If $\frac{X_A}{4X_B} < 0$, then attenuation in

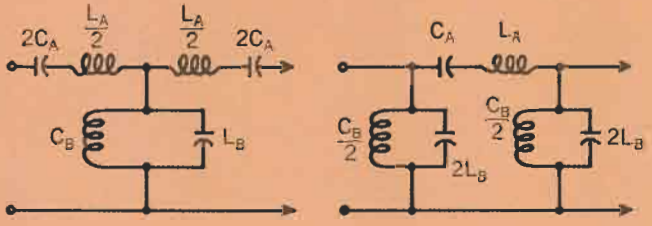
$$\text{dB} = \sinh^{-1} \sqrt{\frac{X_A}{4X_B}}\,(40 \log_{10} e).$$

If $-1 < \frac{X_A}{4X_B} < 0$, then attenuation in dB = 0.

If $\frac{X_A}{4X_B} < -1$, then attenuation in

$$\text{dB} = \cosh^{-1} \sqrt{\frac{-X_A}{4X_B}}\,(40 \log_{10} e).$$

The resulting plot shows the "ideal" frequency response in blue and the frequency response from the commercially available components in orange.

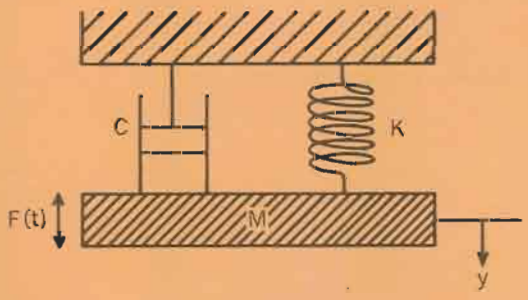


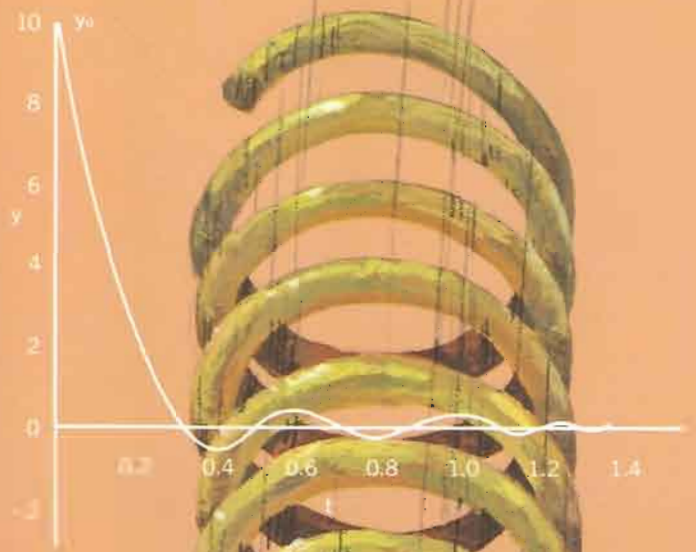
Differential Equations

Non-Linear Vibration

Although this example is given as a vibration problem, the general solution is applicable to second order linear or non-linear differential equations which are common to many fields of interest: $y'' = f(x,y,y')$.

In solving the equation, we are describing the displacement (y) of a mass (M) as a function of time (t): 1. When suspended by a spring with constant (K) and a non-linear damper with constant (C), 2. When given an initial displacement (y_0) and velocity (y'_0), 3. When acted upon by an external forcing function, $F(t)$. The differential equation for this example is: $My'' + C|y'|y' + Ky = F(t)$. The graph shows a typical solution.





Heat Transfer

Another application for the non-linear, second-order differential equation $y'' = f(x,y,y')$ is in solving a heat-transfer problem.

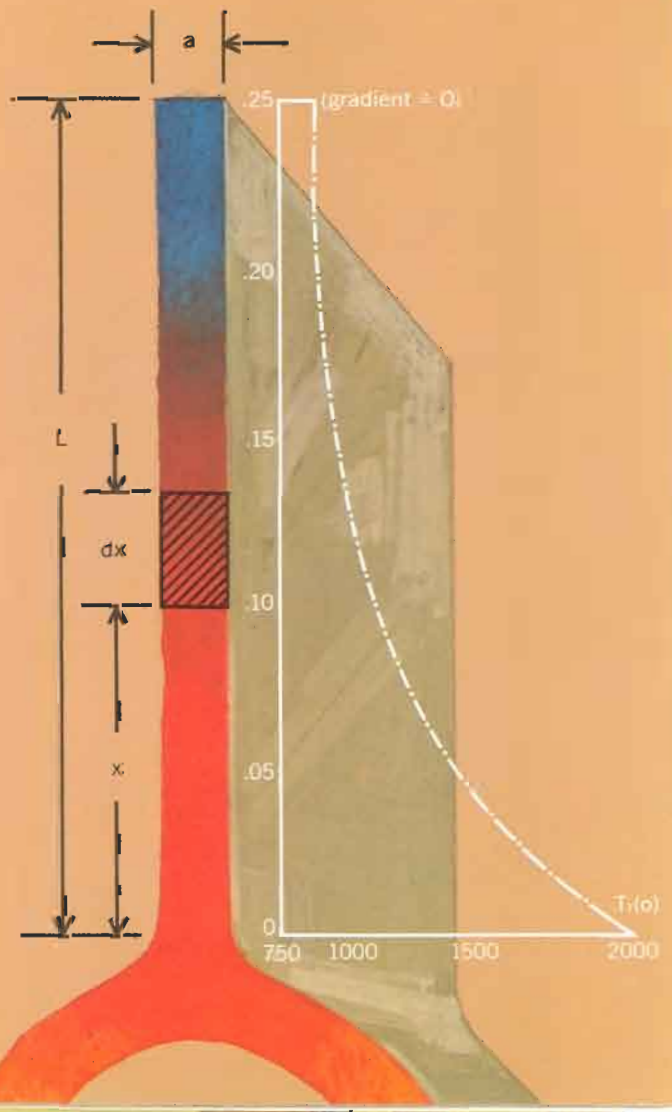
In this problem, we are given the temperature at the root end, T_1 (0); temperature of surrounding space, T_2; and the temperature gradient at the root end, T_1' (0)—of a cooling fin. We need to find the steady state temperature distribution—the temperature T_1 along the fin as a function of distance x from the root end.

The general numerical solution which was developed for the 9100A will solve this equation:

$$T_1'' = \frac{2\sigma\epsilon_1}{ka}(T_1^4 - T_2^4)$$

where σ, ϵ and k are constants, and a is fin thickness.

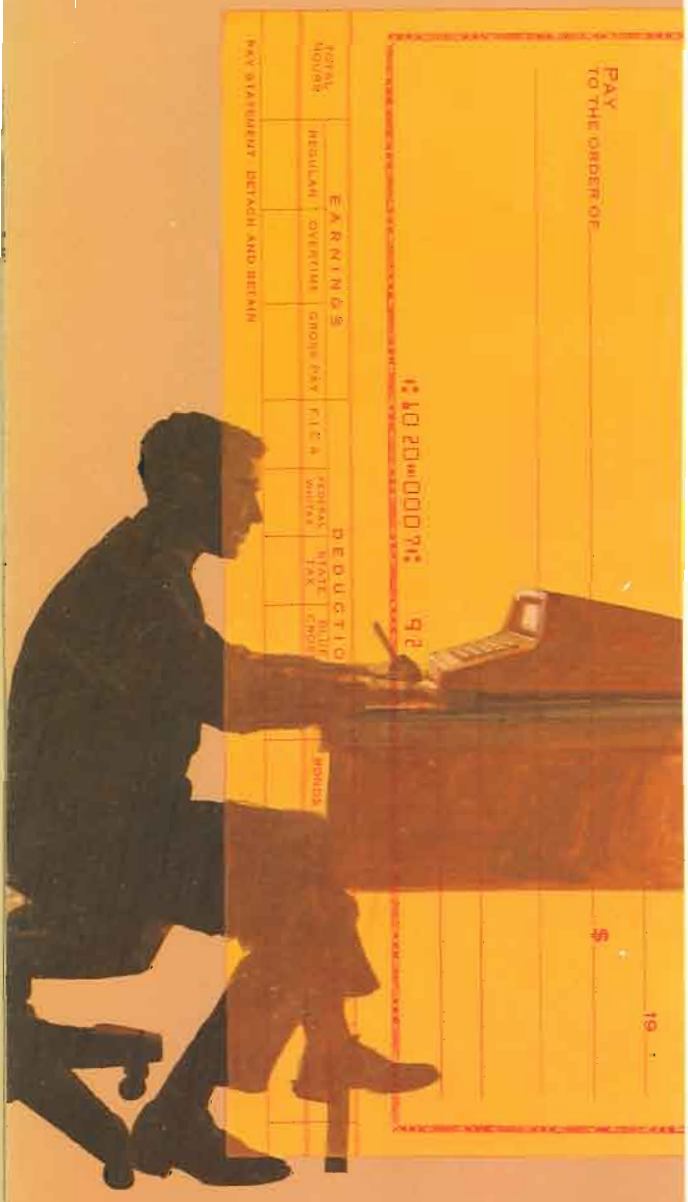
The graph shows the calculated data points.



Business Calculations

Supplement your use of the versatile hp computing calculator for solving your day-to-day engineering and scientific problems by using it for your more complex business calculations.

Programs available in the program library furnished with the 9100A include: Payroll / Depreciation Schedules / Return on Investment / Discounted Cash Flow / Engineering Economics / PERT Calculations / Loan Amortization / Economic Order Quantities / Stock Market Calculations.



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hp 9100A Calculator, Price: $4900.

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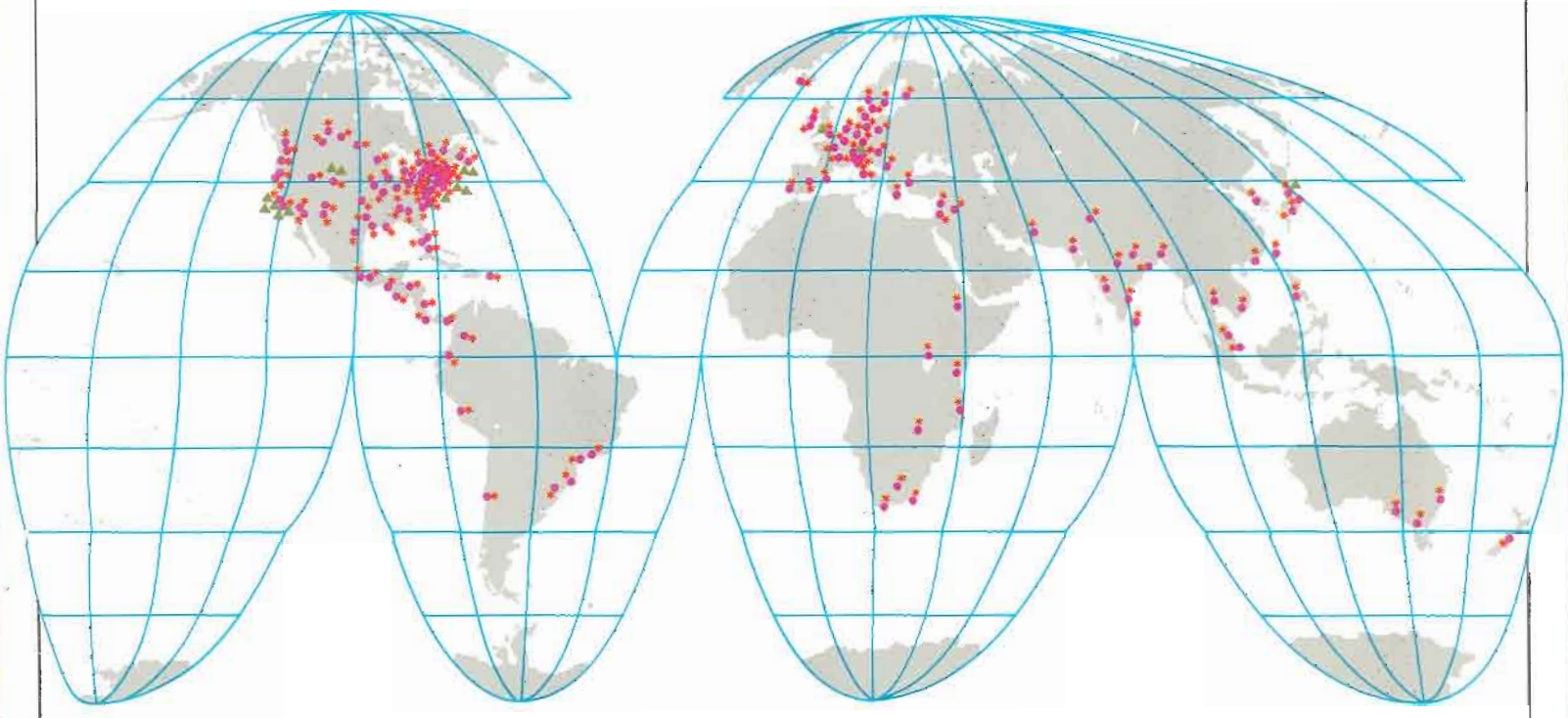

With hp service personnel located in major centers throughout the world, you are assured prompt service. The hp 9100A has highly reliable, all-solid-state circuitry which allows hp to give you a one-year warranty on all materials and workmanship. All circuitry is contained on easily replaceable plug-in circuit boards. Thus, service generally can be performed at your desk. Service contracts and leasing arrangements are available. For full details, contact your nearest Hewlett-Packard field engineer.

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