KEYBOARD

HEWLETT-PACKARD

VOL. 6 NO. 3

OVERVIEW

Teaching complex business concepts, especially those involving economic interactions between countries, has always been a challenge to educators knowing the somnolent effects of the mass of data and charts considered essential to pure pedagogy. The American Graduate School of International Management has developed a different approach which, with the HP 9830A system, brings economics to life and inspires students to the extent that they want to use the equipment to try their ideas at all hours of the night. The feature article on the intriguing concepts used by this school starts on page 1.

Many troublesome artifacts exist in evaluating indicator dilution curves which lead to interpretive errors by the clinician or physiologist. Correction of these artifacts calls for a computing or calculating device which is economical, convenient, and capable of converting input data to output in the shortest time. On page 4 is a description of the San Francisco General Hospital's application of the HP 9810A to perform this essential function.

You can acquire the technique of mentally calculating the day of the week for a particular date without referring to a calendar--or assign the task to your calculator if you prefer. The Crossroads column in this issue is devoted to calendar calculations and how to use them. See page 8.

The programming tips in this issue include some time-saving information that may be rewarding in your calculator applications. If you have any programming techniques you feel are of general interest, other calculator users will appreciate them too. Send them to the nearest *KEYBOARD* editor for evaluation and possible publication.

ABSperry

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FOR HEWLETT-PACKARD CALCULATORS
PUBLISHED AT P.O. BOX 301, LOVELAND, COLORADO 80537**

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International Macro Economics and the HP 9830A

The American Graduate School of International Management is located in Glendale, Arizona, 16 miles northwest of Phoenix. The school includes three sections: International Studies, Language, and World Business. The curriculum, which requires one year to complete, is aimed at qualifying students to become managers in international business and government. The school attempts to hold enrollment down to about 750 students. The average age for students is 26, and many of them have had previous graduate school experience, and/or experience in business. In addition, the average student has lived two years in a country other than that of his birth.

Members of the faculty at the American Graduate School have had extensive academic training, wide-ranging experience in business and government institutions, and often both. They are therefore well qualified to combine theory and application in their teaching approach.

The Hewlett-Packard 9830A Calculator serves several important needs at the school, both as a training aid and, with the 9880B Mass Memory subsystem, as an administrative information system to maintain student records.

COMPUTER TRAINING

Each World Business student is required to take the computer training course, WB331. Although now about 150 students are enrolled in the course at one time, it is estimated that up to 250 students per system can be accommodated later when more systems are available. This training is given using the HP 9830A Calculator with 8K memory; String Variables, Matrix, Advanced Programming, and Extended I/O ROMs; 9869A Card Reader, 9865A Cassette Memory, 9880B Mass Memory Subsystem, and a 2762A Console Printer.

Many students at the American Graduate School will have contact with computer data processing centers in their future careers. This is one reason the HP 9830, with its BASIC programming language, is referred to as a computer or as an introductory step to the computer world, rather than as a calculator. Students accept the fact that it has a calculator or keyboard mode, while learning the concepts and philosophy of managing a computer data processing center.

The computer training is aimed primarily at familiarizing the student with operation and applications of the system and enough flowcharting to understand it, rather than trying to create programmers. However, once familiar with the equipment and the BASIC language, students often design programs of their own or modify existing programs to solve problems in classes where the use of the HP 9830 is not required but is beneficial.

There are several main reasons for making computer training a requirement for World Business students. One is to remove the student's misconceptions about using a computer or terminal and let him feel at home with the equipment. Another reason is to help the student, who will eventually be an international manager, to understand the way programming and flowcharting work, and to enable him to communicate with the data processing center of his company effectively so that he can specify reports that are concise and meaningful to him.

Another reason for the computer training requirement is to prepare the student to use the equipment on his own for economic modeling simulations, as well as accounting and other applications. Once the student has his card certifying completion of the training, he is allowed to operate the equipment without supervision. The HP 9830 is available 24 hours a day, so the student can mark-sense his cards at his convenience, then access the HP 9830 any time it is available and run his program.

All available programs can be purchased by the student on a cassette at a moderate cost, so he always has his own set of programs available. The student has the option of marking his input cards and leaving them for overnight batching, or walking in with his certifying card and running the equipment himself. The student is not required to personally run the HP 9830 after the first four weeks of instruction.

An obvious advantage of having the HP 9830 available 24 hours a day is the elimination of time delays that would occur if the equipment had to be run by staff personnel. The student can personally try his data, and in the case of a one-card or two-card error, reenter the correct information via the keyboard and run his program. Or he can go to the HP 9830 between classes for a fast check of a change he has made.

Use of the marked cards by students helps maximize efficiency of equipment operation. James Lee, data processing manager at the school, estimates that with the present type of usage, the HP 9830 is in use 65% of the time, five days a week, based on the 24-hour day.

In addition to general familiarization with computer operations, the HP 9830 is used by students and faculty for research tools such as multiple regressions, analysis of variance, etc. The HP 9830 is also used by the school as a teaching tool. Two examples of its utilization in the World Business department are in accounting, where students are given actual computer output data used in the HP 9830 to product their own reports, and in economics, where the HP 9830 simulates the potential environment of a decision-maker in international management.

WORLD BUSINESS APPLICATIONS

The American Graduate School offers a complete accounting course based on the Pillsbury accounting system[1]. The HP 9830 produces the trial balance, the trial balance by summary, and a summary by accounts. The student processing the information by hand would generate only the trial balance, so the HP 9830 gives him more information to enhance his understanding. In other operations requiring summary reports, such as bond depreciation, the student enters a one-card parameter and receives as a result a complete table or page of calculations, instead of just the result of one calculation.

[1]Wilbur F. Pillsbury, *Computer Augmented Accounting*. (Chicago: Southwestern Publishing Co., 1970.)

Many students who have taken the accounting course have suggested changes or added applications which could expand and enhance the course, demonstrating their enthusiasm and understanding.

In teaching international macro economics at the American Graduate School, the HP 9830 is used, for example, to work with a simulation model. Professor Dale Vorderlandwehr and Mr. James Lee took the original Fortran[2] program which used a 16K memory, and translated it to BASIC for use with the HP 9830. In doing this, they made some improvements to the model, and at the same time revised it to run in a HP 9830 with a 4K memory.

The simulation in this case involves a two-country world economic model. Included for each country is a consumption function, production function, demand for money function, government expenditures, investment demand, and all the identities normally associated with a standard economic model. In addition, because the game deals with international economics, it includes trade flows and international capital flows. After decisions are made for government expenditures, taxes, investment demand, money supply levels, etc., the HP 9830 is able to solve the values for all the variables in this international economic model in less than a minute.

The program is stored in a mass memory, and for a small fee, the students can purchase cassettes allowing them to keep a record of the results of the consequences of their decisions for as many time periods as they wish. This feature is particularly attractive because of the 24-hour access which makes it possible for students to run the simulation at any convenient time.

INTERNATIONAL STUDIES

This division of the school focuses on preparing students to use the analytical tools of political science as they relate to managerial decision-making in the international sphere.

The International Studies department utilizes computer operations at the seminar level. Professor John Conklin is developing a seminar on policy-making decisions which utilizes the concept of dependency and a model of decision-making based upon socio-political criteria.

Using the HP calculator computer system, students can adjust the 'environment' within which decisions are made and readily observe the impact of socio-political variables upon optimum decisions according to economic criteria.

[2]Peter H. Lindert, *Macro: A Game of Growth and Policy*. (Holt, Rinehart, Winston, Inc., 1970.)

STUDENT RECORD PRINTOUTS FROM MASS MEMORY

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      AMERICAN GRADUATE SCHOOL OF INTERNATIONAL  MANAGEMENT
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                TIME                     Days     Hours Cr.
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                      SUMMER    5/5/1974
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      C600A    CAPSTONE                            DRAKE

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      J40CD    ADV. JAPANESE CONV.                 STAFF

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   3  LENTZ, SUSAN T        S U2  576  934-7369
   4  LODI, ROBERT A        SVU3  539  938-7449
   5  MEAD, PAUL S          SVU2  603  973-2390
   6  MYUNG, KI TAE         M F1  544  938-7139
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   8  YEP, JUDY             S U2 1024  934-7369

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   2  GRANT, JAMES S        S UO  373  938-7337
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   8  TAYLOR, LESLIE RAE    S UW  876     -   0
   9  TOOMEY, ELIZABETH     S UO  653  931-7323
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ESPING, JON A       SVU2 O/C   12       290       261947996            0


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         W310W   MANAGERIAL ACCOUNTING              ..... 00 035 WAIVER
         W320W   ECONOMIC THEORY                    ..... 00 038 WAIVER
         W330W   OPERATIONS ANALYSIS                ..... 00 039 WAIVER
         W340W   INTERNATIONAL MANAGEMENT           ..... 00 031 WAIVER
         W350W   INTERNATIONAL MARKETING            ..... 00 029 WAIVER
         ENGL.   EXEMPT/ENGLISH                     ..... 00 007 WAIVER

                                      Total Cr. Hrs     15

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         W547C   MULTINATIONAL CORP. PLANNING        M W  03   11 WOODRUFF
         I427A   ECONOMIC HISTORY,EUROPE             M W  03   13 WEINER
         F40CB   ADV. FRENCH CONV.                   M WT 03    5 STAFF
         W310W   MANAGERIAL ACCOUNTING              ..... 00 036 WAIVER
         W320W   ECONOMIC THEORY                    ..... 00 039 WAIVER
         W330W   OPERATIONS ANALYSIS                ..... 00 040 WAIVER
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                                      Total Cr. Hrs     12

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         W450A   ADV.INTNL.MARKETING                 M WT 03   32 SHERIDAN
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         S3AFA   BEGINNING SPANISH, FUND.            T T  00   20 STAFF
         I370W   INTNL POL ANAL/3 CREDITS           ..... 00 001 WAIVER

                                      Total Cr. Hrs     12
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ADMINISTRATIVE APPLICATIONS

The HP 9830 with a 9880B Mass Memory subsystem is being used at the American Graduate School for registration and student records. In registering, the student gets a control card which is filled out with his essential information such as address, social security number, student P.O. box number, previous degrees and parents' names and address. He picks up a punched card for each class in which he is enrolling, and then turns in the set of cards. The cards are entered into the system through the 9869A Card Reader, and the individual student records are recorded on the mass memory platter. Once all student records are entered, summary reports are run with all student locator information.

Many reports can be generated with the large amount of student information contained in the mass memory by searching the records for a particular variable and printing out the result. Some of the reports currently used include a list of all foreign students and what countries they are from, a Veterans' Administration locator, and a report with required information to the Veterans' Administration.

The administative function using the mass memory is performed entirely using just one platter of the memory. The other platter contains various economics and accounting programs which the students can access and use. Since the platter can be removed from the mass memory, the confidentiality of such information can be safeguarded.

CONCLUSION

A decision was made by the American Graduate School to buy the HP 9830 Calculator system after leasing it for several months. An HP 2607A Line Printer will be added to the system to enable it to print output at up to 200 lines per minute with a 132-column width.

The system has proven itself capable well beyond the initial expectations for both scholastic use in teaching and administrative applications. With its BASIC programming language and versatility, the HP 9830 system is an excellent training medium for future managers dealing with data processing centers, as well as a capable tool for administrative applications--in other words, an ideal answer to the computation problems of an institution such as the American Graduate School of International Management.

The HP 9810A at San Francisco General Hospital

A MODEL 10 PROGRAM CORRECTING ARTIFACTS IN THE EVALUATION OF INDICATOR DILUTION CURVES

by Richard B. Fuchs and James W. Holcroft, B.S.E.E., M.D.

Supported by NIH Grant GM-18470 and Army Contract DADA-17-72-C-2030.

Indicator dilution curves are widely used as a minimally destructive means of determining flow through physiological circuits. Ordinarily a bolus of indicator is injected and its concentration serially measured downstream from the injection site. Plotting changes in concentration against time gives a growth-decay curve (Fig. 1) related to flow by the formula

$$\text{flow} = \frac{\text{dose injected}}{\int_0^\infty C\,dt} \tag{1}$$

where C is indicator concentration and t is the time. Mean transit time, the average time necessary for indicator to traverse the circuit, is given by adding to the appearance time the first moment of the curve:

$$\text{first moment} = \frac{\int_0^\infty t\,C\,dt}{\int_0^\infty C\,dt} \tag{2}$$

Physiologists and clinicians have sought to apply the mean transit time to the estimation of parameters such as central blood volume [3], extravascular lung water, and left ventricular volume [1], often with good success. Success, however, depends on minimizing distortion introduced by the measuring apparatus, and more widespread clinical use of these determinations may await the development of cheap analog systems capable of reversing sampling artifacts. Our attempts to refine the measurement led us to try two large computer-digitizer packages. These proved unsatisfactory because of their frequent inaccessibility and inadequate software. Our HP 9810A, which we had initially overlooked in the belief that a much larger core capacity would be needed, provided an ideal combination of convenience and economy. We now find we can evaluate the average curve in about two minutes with 99% accuracy. Users whose packages include a HP 9864A Digitizer should get speed and definition comparable to the analog systems we have envisaged.

Procedures for evaluating the curve's integral are well established[2,3]. Typically, the initial portion of the curve is summated up to the point on the downslope closest to 70% of peak value (Fig. 1). From 70% to about 35% of the peak the curve has an exponential form,

$$C = {}_eA \times {}_eBt, \tag{3}$$

which can be rewritten as

$$\ln C = A + Bt, \tag{4}$$

and extrapolated to nullify the effect of indicator recirculation. Substituting the intercept A and regression coefficient B into the expression

$$\frac{{}_eA + Bt}{B} \Bigg|_{T_{70}}^{\infty} - .5\,DT, \tag{5}$$

where T_{70} is time at 70% peak value, gives the area under the exponential part of the curve. By adding this to the numerically integrated portion one gets the integral for the entire curve. In many laboratories these integrations are performed by dedicated analog computers purchased as a component of the measuring system; but for our studies these proved inadequate on two grounds. First, many of our curves had an elongated flat configuration which failed to satisfy the computer's input requirements or overloaded its summating capacity. Second, as we have indicated, the computer made no correction for the filtering characteristics of our measuring systems.

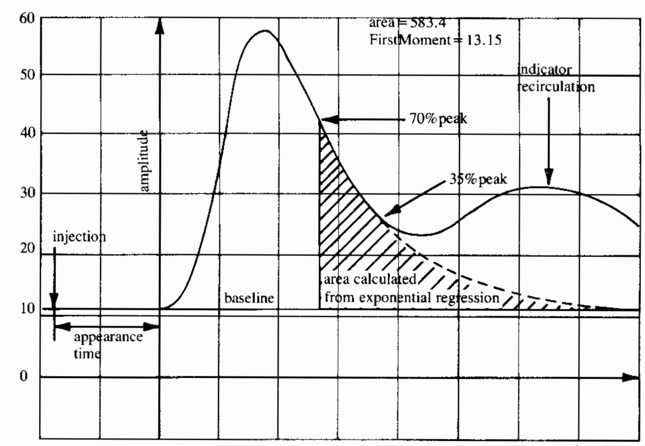


FIGURE 1. Indicator dilution curve before transformation

These systems respond to a step function with a curve (Fig. 2) such that,

$$\text{output} = \text{input} \quad (1 - e^{\frac{-1}{\tau} T}) \tag{6}$$

where T is time and τ is the time constant, or the time by which the output has reached 63.2% of the input amplitude. Because this artifact has little effect on the value of the integral in (1), it can be ignored in most flow calculations. For computation of the first moment, however, a correction for the artifact is necessary. Following the theory of function transformations, (6) may be rewritten as:

$$C = C_0 + \tau \frac{dC}{dt} \tag{7}$$

where C is input or in *vivo value*, C_0 is output, and dC/dt is the slope about C_0. By applying (7) to each point computed, one restores the curve to its original or input shape (Fig. 3).

Our program was written for equipment on hand, a basic HP 9810 calculator with alpha and stat ROM's. This hardware package limits data entry to 37 points, enough for any curve in our experience. Very long curves which overrun storage capacity may be integrated with negligible loss in accuracy by lengthening the time interval DT, and shorter curves may be more finely resolved by shortening it. With each entry the value of the point preceding is corrected and printed out minus baseline, followed by the number of the current entry and its uncorrected value. For convenience, points may be entered with baseline value included; the program subtracts the baseline before calculating slope, and adds it on again for the printout of the uncorrected point. Having defined peak as the first corrected value followed by a smaller one, the program finds the values closest to 70% and 35% peak and proceeds to calculate the area and first moment.

The output portion also provides for revision of the computations. R^2 and the coefficients for the exponential regression are printed out as a check on goodness of fit and for calculation of left ventricular volume, respectively. In short curves where the regression is performed on only two points, the user may wish to include a third one to make the R^2 statistic meaningful. This he may do by indicating new points in the redo option at the end of the program or by decreasing the value of the time interval. The program's peak-finding feature may give erroneous results with occasional very noisy curves or with systems having long time constants. In such cases, where a transient negative slope occurs before peak value, the program will calculate wrong values for 70% and 35% peak, producing an error in the exponential computations. To override this error the user selects the true 70% and 35% points from the transformed points printed out after each entry and inserts their interval numbers in the redo option.

Symbols used in the program:

B = baseline value
TAU = time constant
DT = value of time interval
C = observed concentrations
T_{70} = number of entry closest to 70% peak
T_{35} = number of entry closest to 35% peak
R^2 = square of the correlation coefficient for the exponential regression
E^A, B = regression coefficients in (5)
Area = integral of the curve
MMT = first moment of the curve

The algorithm used to calculate slope about C_0 is

$$\frac{dC}{dt} = \frac{C_0 + (C_{0+1} - C_{0-1})}{2\,DT}$$

where C_{0-1} and C_{0+1} are the observed values preceding and following C_0.

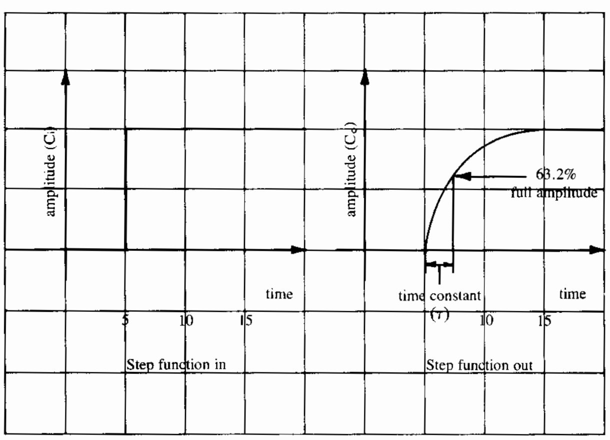


FIGURE 2. Distortion of step function

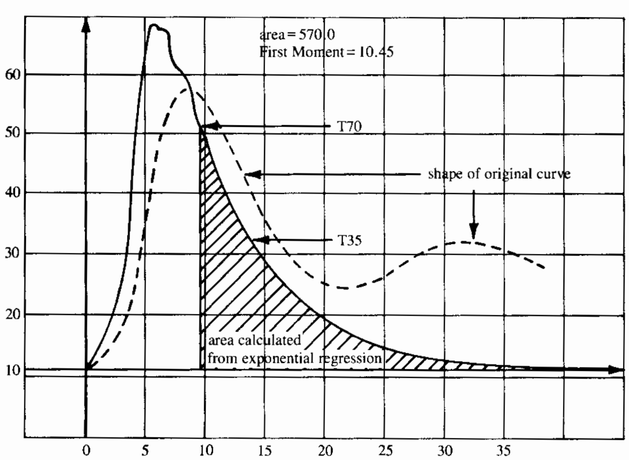


FIGURE 3. Curve after transformation

EXAMPLE

For this example the curve in Figure 1 will be evaluated. Base, time constant, and time interval are entered as called for. Concentrations are entered seriatim until the program has found T_{35}, at which point it automatically completes the calculations and presents the redo option. At this point new values may be inserted and the flag set. If no redo is desired, pressing "continue" returns the calculator to the beginning of the program.

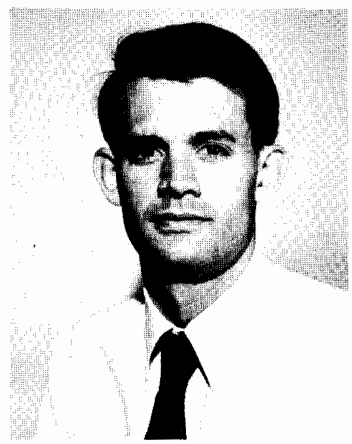
```
B→Z
TAU→Y
DT→X
          11.000
           2.300
           1.000

C...=
           1.000*
          11.900
           4.235

           2.000
          13.900
           8.190

           3.000
          16.500
          14.815

           4.000
          22.000
          31.125

           5.000
          34.000
          50.600

           6.000
          46.000
          57.425

           7.000
          53.500
          54.230

           8.000
          56.200
          48.995

           9.000
          56.800
          44.420

          10.000
          55.000
          38.020

          11.000
          51.600
          32.550

          12.000
          48.000
          28.490
```

```
                    13.000
                    44.200
                    24.000

                    14.000
                    40.000
                    19.570

                    15.000
                    36.000
T70=
T35=
                    10.000
                    14.000
 2
R  =

 A
E  =
B  =
                     0.994
                   197.165
                    -0.163

AREA=
MMT=
                   569.972
                    10.452

REDO?
T70→Y
T35→X
T70=
T35=
                     9.000
                    14.000
 2
R  =

 A
E  =
B  =
                     0.996
                   189.918
                    -0.160

AREA=
MMT=
                   572.750
                    10.521
```

REFERENCES

1. Grodins, F.S., "Basic Concepts in the Determination of Vascular Volume by Indicator-Dilution Methods," Circulation Research, 10:429 ff., 1962.
2. Hamilton, W.F., "Studies on the Circulation, Part IV," American Journal of Physiology, 99:534 ff., 1932.
3. Stewart, G.N., "The Pulmonary Circulation Time, the Quantity of Blood in the Lungs, and the Output of the Heart," American Journal of Physiology, 58:20 ff., 1921.

Richard Fuchs is a Staff Research Associate at the University of California, San Francisco General Hospital Trauma Center, where he is in charge of statistics, programming, and development of data acquisition systems. He attended Harvard University and has worked in physiological research since 1967.



James W. Holcroft is a fifth year surgical resident at the University of California San Francisco Medical Center. For the past two years he has been studying lung damage following hemorrhagic shock in baboons. He received his B.S. in electrical engineering from M.I.T. in 1963, and then taught mathematics in the College of Agriculture of the University of the Philippines while serving in the Peace Corps. He graduated from Western Reserve Medical School in 1969.

Recent Contributed Programs

Many interesting programs are received at Hewlett-Packard's Calculator Products Division in Loveland, Colorado. It is not possible to publish all of these, but since a number of programs are of general interest, KEYBOARD will announce programs in this category from time to time. More information on any of these programs can be obtained by contacting the contributor. Here is a list of some recently submitted programs.

Title: Base Conversion
Equipment: HP 9810A, 2036 steps, Printer; Printer Alpha and Math ROMs.
Description: This program converts numbers between the Hexadecimal, Decimal, Octal, and Binary systems.
Author: William E. Holmes
National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

Title: Binding Equation
Equipment: HP 9810A, Printer; Math and Printer Alpha ROMs.
Description: This program calculates the free ligand concentration in cases of multiple binding to proteins for up to 10 classes of binding sites.
Author: Dr. J.W. Stucki
Pharmakologisches Institut
Friedbühlstrasse 49
CH-3008 Bern, Switzerland

Title: Datapoint
Equipment: HP 9830A, 9866A
Description: This is a compact, code-efficient routine which plots, on the 9866A, data points with unique identifiers; used for quick plots of experimental data to check for continuity and experimental accuracy.
Author: Lt. James W. Sturges, USN
Department of Aeronautics (Code 31)
U.S. Naval Postgraduate School
Monterey, California 93940

Title: Football Game
Equipment: HP 9821A, 1191 registers; Math and P.C.1 ROMs; 9862A
Description: This program allows simulated football play between two teams. Nine types of plays are allowed, including runs, quarterback sneaks, passes, kicks, etc.
Author: John Volzer
Hewlett-Packard Co.
1430 East Orangethorpe
Fullerton, California 92631

Title: Functions of Six Indices Permutations
Equipment: HP 9810A, 1012 steps, Printer; Math and Printer Alpha ROMs.
Description: This program calculates functions of all necessary permutations of Miller indices of one plane in crystal with all necessary permutations of second plane.
Author: Prof. Arie Dooby
University of the Negev
Physics Department
Beer Sheva, Israel

Title: Game of Life
Equipment: HP 9810A, 111 registers, Printer; Math and Printer Alpha ROMs.
Description: This program enables the calculator to play the game of "Life" which, according to Time Magazine (Jan. 21, 1974) was invented in 1970 by John Horton Conway of Cambridge University.
Author: Lt. Peter M. Fried
1719 Norman Way
Madison, Wisconsin 53705

Title: Point Plotting
Equipment: HP 9830A, 9866A, 9862A, Plotter Control ROM.
Description: This program was designed for the nonprogrammer who wants a simple scatter diagram. It will plot values in one or two of four quadrants.
Author: Jerry W. Highfill
U.S.A. Medical Bioengineering R & D Laboratory
Aberdeen Proving Ground, Maryland 21010

Title: RISC:Radioimmunoassay Standard Curve Determination and Dose Interpolation*
Equipment: HP 9100A, 9101A, 9106A or 9120A
Description: This program will determine a weighted least squares regression line through a series of data points (up to 50) representing the radioactivities of standard dosages of immunoassayable material. A choice between two weighting algorithms is provided.
Authors: Paul R. Gouin, M.S. and Robert T. Rubin, M.D.
B4 Neurological Laboratory
Harbor General Hospital
Torrance, California 90509
*Supported in part by ONR Contract N00014-73-C-0217

Title: Simple Span Moments, Shears, and Deflections
Equipment: HP 9830A, 7616 bytes, 9866A
Description: This program computes moment, shear, and deflection bounds for simple span beams under live load, dead load, and moments from adjacent spans.
Author: James A. Gerwig, P.E.
Gray, Rogers, Myers & Morgan
601 College Road
Fairbanks, Alaska 99701

Title: Stack Sample 1
Equipment: HP 9810A, 1012 steps
Description: This program reduces stack test data, calculates particulate concentration in 8 different units, and compares results with limits. Obtains gas composition.
Author: Max Reinnoldt and Dick Ohl
Milwaukee County Department of Air Pollution Control
9722 W. Watertown Plank Road
Wauwatosa, Wisconsin 53226

Title: Truth Table for 2 to 5 Variables
Equipment: HP 9830A, 9866A
Description: This program prints the truth table of any Boolean function for 2 to 5 variables.
Author: G. Georg, dipl. Ing. ETH
Swiss Federal Institute of Technology
Institute for High Frequency Electronics
Sternwartstrasse 8
CH-8006 Zurich, Switzerland

THE Crossroads

CALCULATIONS ON THE CALENDAR

By John Nairn, Ph. D.*

. . . He His fabric of the Heav'ns
Hath left to their disputes, perhaps to move
His laughter at their quaint opinions wide
Hereafter, when they come to model Heav'n
And calculate the Stars.
John Milton, Paradise Lost

On what day of the week were you born? On which day of the week will the year 2000 begin? The natural reaction to these questions is to scurry about to find a calendar for the given year, and look it up. Or if you happen to have one of the new business-oriented calculators, you will find a key which can calculate the day of the week for a given date. Although hardly a day goes by in which we don't make use of a calendar, we tend to think of it as a complex and irregular tool. Each month has a varying number of days, there is no apparent regularity in the day on which a month begins, and leap years make the whole thing beyond comprehension. And yet few things are more regular and predictable than the yearly motion of the earth about the sun, on which the calendar is based. What then is the source of the seeming irregularity?

In a year, there are 52 weeks of 7 days each for a total of 364 days. Since it takes the earth 365 days to complete its yearly orbit, a given date in one year should be one day of the week later than in the previous year. The problem, however, is that the actual time for the yearly revolution of the earth is 365.2422+ days. The history of the calendar is the history of the attempts to reconcile this difference from an integral number of days.

Early calendars contained 365 days and ignored this discrepancy, so that by the year 46 BC, the Roman Republic calendar was three months out of step with the astronomical equinox. Julius Caesar, on advice from the Alexanderean astronomer Sosigenes, instituted a new calendar of 365 and 1/4 days in which every fourth year contained an extra day to allow for this difference. Caesar changed the name of the month Quintilis to July, in honor of himself. This Julian calendar served quite well until the 16th century, when the Roman church became aware that the slight discrepancy remaining was causing Easter to slip into February. To correct this, Pope Gregory XIII commissioned the astronomer Aloysius Lilius to devise a more accurate calendar to coincide with the actual length of the year. He determined that every fourth year should be a leap year, unless it is a multiple of 100, in which case it would not be, unless it is a multiple of 400, in which case it would be. Confusing as it may seem, this means that there are 97 leap years in each 400, which gives an average calendar year of 365 + 97/400 = 365.2425; not a bad approximation. This Gregorian calendar, which we use today, was adopted in most of Europe in 1582. To make up for the lost days which had accumulated since the Julian Calendar's adoption, the day following October 5, 1582, was proclaimed October 15.

*Calculator Products Division, Hewlett-Packard Company, Loveland, Colorado

Under this new system, each date is one day later in the following year, and two days later in leap years. Theoretically, if you know the day of the week for a given date in one year, you could by counting in this way calculate the day for the same date in any other year. But this regularity also makes it possible to devise a general formula for calculating the day of the week for any given date without the use of any calendar. This method, or algorithm, is the basis for those used in business calculators which do this kind of calculation. Indeed, with a little practice you can learn to do the calculations in your head for a fine parlor trick!

The only difficult task is to memorize the list of twelve numbers, called the month codes, associated with each month, and given in Table 1.

JAN	1	JUL	0
FEB	4	AUG	3
MAR	4	SEP	6
APR	0	OCT	1
MAY	2	NOV	4
JUN	5	DEC	6

TABLE 1. Month Codes

As a memory aid, notice that the first three numbers equal 12 squared; the next three, 5 squared; the next three, 6 squared; and the last three, two more than the first three.

The general formula, then, is:

$$W = MC + D + Y + INT(Y/4),$$

where MC is the month code, D is the day of the month, Y is the last two digits of the year, and INT(Y/4) means to divide Y by 4 and keep only the integer portion. Once you have W, cast out any multiples of 7 and keep the remainder. What is left is a number between 0 and 6 which gives the day of the week, with Saturday = 0, Sunday = 1, Monday = 2, etc.

For example, let's do June 16, 1945. The month code is 5, D = 16, Y = 45, and INT(Y/4) = 11, giving W = 77. Now, 7 divides 77 eleven times with a remainder of zero. Therefore, June 16, 1945 fell on a Saturday. When you do the calculation in your head, you can cast out 7's as each term is added, so you never have to keep track of an intermediate result greater than 6.

Finally, if the year is a leap year and the month is January or February, you must move back one day in the week.

When I am conducting training sessions on the 9800 series calculators, I like to give this problem as a programming exercise since its solution involves a good number of nontrivial programming problems such as converting the month number to its month code, casting out sevens (a mathematician would call this modulo 7 arithmetic), and the use of Boolean operations to account for leap years. I have not determined how tightly this program could be compacted on any of the calculators, and would be interested in results from any readers who try it.

This method is good for any date in the 20th century. Can the reader find the correction term to make it general for any century before it is given in a later article? With this correction, the method is good for any future date, and prior dates back to 1752. Since the Gregorian calendar was adopted in Europe in 1582, but not in English speaking countries until 1752, dates before 1752 are ambiguous. In England and America, the day following September 2, 1752 was September 14. Ignorance of the need for this adjustment actually led the colonists to believe that this was another repression by the king, and caused riots and cries of "Give us back our eleven days!"

An unrelated, but interesting calendar problem involves a "perpetual calendar" sold commercially and seen in the sketch in Figure 1.

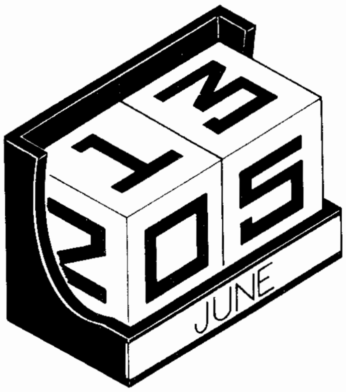


FIGURE 1. Perpetual Calendar

The two cubes can be rotated and interchanged to show all the possible dates from 01 to 31. The problem is to determine the numbers that appear on the six faces of each cube to make this possible. The zero must appear on one-digit dates as shown in the figure. Otherwise, if only one cube were used, after ten days the owner would almost certainly misplace the other cube and render useless a most interesting device.

Following are the answers to the problems given in the Crossroads article on Boolean algebra.

The two-out-of-three vote of the committee would be represented as a*b + b*c + a*c. Some readers suggested using a + b + c ≥ 2. This would be all right if a yes vote were always represented by 1. Recalling that all non-zero values represent true (=yes), only the first solution would guarantee a correct result in all cases.

The required expressions for finding the minimum of two values, X and Y, is MIN(X,Y) = X*(X<Y) + Y* (Y≤X). If X and Y are about the same size so that round-off error is not a factor, one Boolean test is sufficient: MIN(X ,Y) = X + (Y-X)*(Y⟨X). The function MAX(X,Y) is the same with the tests reversed.

FRACTION RATIONALIZATION CONTEST RESULTS

A choice of any available program pac goes to R.M. Holford of Atomic Energy of Canada Limited, Chalk River, Ontario, as the winner of the contest announced in *KEYBOARD* Vol. 5 No. 4 for a program to rationalize decimal fractions rapidly and obtain a specified accuracy. Mr. Holford submitted a program using a continued fraction of the form:

$$X \approx K_1 + 1/(K_2 + 1/(K_3 + \ldots + 1/(K_n - K)))$$

The HP 9820A program allows the user to specify his desired accuracy. As an added feature, it gives the option of either printing out the rationalized final minimal solution together with its absolute and relative error or, by setting a flag, printing out the successive convergents and their accuracy until the user-specified accuracy is reached. An example of the printout for rationalizing π is shown below.

```
X
 3.141592654E 00
MAX REL ERROR
 1.000000000E-11

A , B
              312689
               99532
A/B
 3.141592654E 00
ABS ERROR
 1.000000000E-11
REL ERROR
 3.183098862E-12
```

Although some of the other contest entries give faster final answers, none give the user's choice of specified accuracy with true minimal solutions. In judging the entries, only the algorithm used and the calculating time were considered, excluding machine printing time.

Honorable mention in the contest goes to J. Van Hecke of Verenigde Energiebedrijven van het Schedleland, Deurne, Belgium, for his 9100A/B program using the same algorithm.

The other contestants were:

James Conragen, Signetics Corp., Sunnyvale, California (HP-35)
Paul Hueber, Adult Clinical Research Center, Upstate Medical Center, Syracuse, New York (9810A)
Albert E. Schmidt, Blonder Tongue Laboratories, Inc., Old Bridge, New Jersey (9820A)
Frank H. Taylor, P.E., Otis Engineering Corporation, Dallas, Texas (9810A)
Alan Wray, Fayetteville, Arkansas (9810A).

Our thanks go to all contestants for their participation. Suggestions for other *KEYBOARD* contests will be welcome.

Letters to the Editor

Dear Sir,

The programming tip for 9100A/B — 9120A printout identification by Mr. Wooding (*KEYBOARD*, Vol. 5, No. 4, p. 19) does not work with our 9100B calculator. For example, after the first increment of 1 the display does not show d 01. but d 06.. However, after the following increments the "program" works well. To avoid this problem I'll propose the following sequence of program steps which can be used as a part of a program. The sequence can, for example, be the last part of the program and, then, the last free register is reserved for it. The program steps could, thus, be:

d.0	8	10
d.1	GTO	44
d.2	d	17
d.3	d	17
d.4	YTO	40
d.5	YTO	40
d.6	YTO	40
d.7	YTO	40
d.8	YTO	40
d.9	a	13
d.a	2	02
d.b	YTO	40
d.c	YTO	40
d.d	END	46

It is important that, in the register selected, the characters from -.4 to -.c are filled like in this example. Adding sequential 1's would then give a01., a02., ..., a99., b00., b01., ..., b99., etc. The alpha a (step -.9) can be replaced by b, c or d. If 1 is used instead of 2 (step -.a) the display will be in the form a0., a1., etc. During the program execution, recalling and incrementing is as it is in Mr. Wooding's tip. The advantage of my program tip is that the whole operation for the printout identification can be included within the program.

Sincerely yours,

Martti Lehtinen, Mineralogist
Dept. of Geology and Mineralogy
University of Helsinki
Snellmanink. 5, P.O. Box 115
SF-00171 Helsinki 17
Finland

ERRATA

In the Crossroads article in *KEYBOARD* Vol. 6 No. 2, there were several typographic errors. The sentence starting on the last line on Page 15 should read:

Symbols may be linked by operations such as AND, OR, and NOT symbolized by p*q, p+q, and $\overline{p}$ respectively.

The equation at the bottom of page 16 should read:

$$D(M) = 31 * (M-1) - INT (2.2 + 0.4*M)$$

and the equation at the top of page 17 should read:

$$D(M) = 31 * (M-1) - INT (2.2 + 0.4*M)*(M>2).$$

In the programming tip, in the right column on page 28 of the same issue, the first equation should read:

$$ds = dx \sqrt{1 + (A\ dy/dx)^2}.$$

1974 CALCULATOR SYSTEM APPLICATION CONTEST

Outside - U.S.A. Deadline Extended

KEYBOARD has been conducting a contest for unusual applications of HP programmable desktop calculator systems. To allow the greatest opportunity for equipment diversity, as well as variety of applications, this contest includes 9100A/B systems in addition to the 9800 series.

Two branches of the contest have been held with different time limits to allow equal opportunities for participation by calculator users in all countries. The U.S.A. branch contest deadline was June 15, 1974. For all other countries the deadline has been extended to September 17, 1974. Winners will be announced as soon as they are determined for both branches.

The winner of each branch of the contest will receive his choice of an HP-45 or an HP-80 Pocket Calculator, or an equivalent value prize in the form of a 9800 series plug-in Read-Only Memory or HP calculator software. Additional rules are:

1. Each entry shall be in the form of an article suitable for publication in *KEYBOARD*, and a publication release shall be included.

2. The inclusion of programs used in the contest application is desirable but not essential to win. Each program submitted shall be fully documented and include a program submittal form found in the back of most HP software pacs.

3. Entries shall be typed double-spaced on paper approximately 8-1/2 by 11 inches (21,6 cm by 27,9 cm).

4. Pertinent photographs, charts, and other illustrations shall be included. Photographs must be good contrast black-and-white prints between 4 by 5 inches (10,1 cm by 12,7 cm) and 8 by 10 inches (20,3 cm by 25,4 cm). The author's photograph and curriculum vitae should be included.

5. Entries shall be submitted to either a field editor or directly to HP *KEYBOARD*, P.O. Box 301, Loveland, Colorado 80537, U.S.A. postmarked not later than the deadline date.

6. Entries become the property of Hewlett-Packard and cannot be returned.

7. A proof copy of any article to be published will be submitted to the author for approval prior to publication.

8. Employees of Hewlett-Packard Company, its affiliates and subsidiaries are not eligible to compete.

PROGRAMMING TIPS

DOUBLE UNARY MINUS (9820A/9821A)

R.M. Holford of Deep River, Ontario, Canada, who is the winner of the Fraction Rationalization Contest, sent us the following HP 9820A or 9821A programming tip.

A double unary minus (--) can sometimes be used to force a change in the normal hierarchy of various operations in a program line, as illustrated in the following sequence to print the Fibonacci number series:

Program

```
0:
FXD 0;PRT 0→X,1→
Y⊢
1:
PRT --X+(Y→X)→Y;
JMP 0⊢
2:
END ⊢
R419
```

Output

```
0
1
1
2
3
5
8
13
21
34
55
89
.
.
.
```

In the above program, the double unary minus in Line 1 takes priority in the operational sequence, and the value in X is stored in a temporary location before the action indicated by the parentheses is taken. Removing the double unary minus results in the output below, since the highest operational priority is then removal of the parentheses; the value in Y is stored in X first, so the original X value is lost.

```
0
1
2
4
8
16
32
64
128
256
.
.
.
```

FAST CIRCLE PLOT (9820A/9821A)

This HP 9820A or 9821A routine for fast plotting of a circle (up to 10 points or more per second) was submitted by Sy Ramey of the Hewlett-Packard Santa Rosa Division. It takes the 9820A or 9821A, 9862A, Math and P.C.1 ROMs. The user sets equal X and Y limits manually on the plotter. The routine requires pressing SET FLAG to terminate plotting and move the pen away from the plotting area after the circle is completed.

```
0:
SCL -1,1,-1,1;
DSP "ADJ TO SQUA
RE";STP ⊢
1:
ENT "SCALE=?",C,
"RADIUS=?",X/C→X
;0→Y⊢
2:
COS (5/√X→C)→A;
SIN C→B⊢
3:
GTO +0;PLT X,Y;A
(X→Z)-BY→X;AY+BZ
→Y;IF FLG 0;GTO
+1⊢
4:
LTR 1,1;END ⊢
R405
```

Note that the speed is attained by first plotting a point on the specified radius, then successively rotating the axes using a routine involving only simple multiplication, addition, and subtraction. Mr. Ramey advises that this technique is applicable to linear sine wave plots and function plots such as sin x/x.

NULL STRING ENTRY ON 9830A

This programming tip was suggested by Dennis Eagle, Hewlett-Packard Calculator Products Division.

If you have a HP 9830A with alpha string capability, there are times when in the Program mode, you would like to input a null or empty string. For example,

```
10 DIM A$[80],E$[80]
20 DISP "EMPLOYEE'S NAME";
30 INPUT E$
35 PRINT E$
40 IF LEN(E$)=0 THEN 70
50 A$=E$
60 GOTO 20
70 DISP "DONE"
80 END
```

To input a null string, enter a quotation mark (") and press EXECUTE.

The BASIC compiler uses the quotation mark as indicators for the beginning and ending of strings, for example, A$="ABC". If there are no characters between the quotation marks (A$=" "), then the string is empty and its length is zero.

S.F. KEY PROGRAMS USED IN PROGRAM (9830A)

Our thanks go to K.S. Wilkinson, Wellington, New Zealand, for submitting the following programming tip.

To use Special Function key programs--defined by Math Pac or other cassettes--in programs rather than manually, first load the keys from the cassette, then store the required key programs one at a time in separate files on another tape (HP 9830A Operating and Programming manual, p. 6-7). Load the separately filed programs into the main memory in sequence, chaining them together. Replace the END statements with RETURN, and call the programs as subroutines. (Subroutines rather than functions must be used to pass several variables back to a mainline program.)

SPEEDING 9830A EXECUTION TIME

John Bidwell of Hewlett-Packard's Calculator Products Division suggested the following technique to speed up HP 9830A program execution time.

The HP 9830 spends a significant amount of its execution time searching for variables in the symbol table. The deeper a symbol is in this table, the longer the search time. To achieve a saving in execution time of large programs with many variables, highly used variables can be put at the best location in the symbol table. The rules for where variables are in the symbol table are as follows:

Searched first (best execution time):	1. Last simple variable encountered during EXECUTION
	2. Previous simple variables
	3. Common Statement (first variable searched first).
	4. lst DIM Statement (first variable searched first)
Searched last:	5. Other DIMs (smaller line #'s are better)

Example

```
10   COM A,B,C
20   DIM D,E,F
30   Z = 1
40   DIM G,H,I
50   X = 1
      .
      .
      .
1000 END
```

Symbol Table

	Symbol	
Searched first:	X	simple variables
	Z	simple variables
	A	COM
	B	COM
	C	COM
	D	1st DIM
	E	1st DIM
	F	1st DIM
	G	last DIM
	H	last DIM
Searched last:	I	last DIM

In the example, if no new variables were encountered, 'X' would remain at the top of the symbol table and should be highly used (as FOR LOOP, counter variable, etc.). 'Z' and on down the symbol table should be the next, and on down most highly used variables. Therefore, by finding the most highly used variables in an existing program and initializing them at the appropriate point in the program, a significant saving in execution time can be achieved.

RECTANGULAR TO POLAR COORDINATES (9820A/9821A)

Sy Ramey of HP's Santa Rosa Division submitted the following HP 9820A or 9821A program line to convert from rectangular to polar coordinates, expressing the resulting angle in the range from -180 degrees to +180 degrees. The polar magnitude is returned to the X register and the angle to Y.

```
1:
SFG 14⊢180(0>X)(
2(0≤Y)-1)+ATN (Y
/X)((√(XX+YY)→X)
≠0)→Y⊢CFG 14⊢
```

Examples

```
X COORD =                X COORD =
        20.000                  -15.000
Y COORD =                Y COORD =
         1.000                   -2.000

MAGNITUDE =              MAGNITUDE =
        20.025                   15.133
ANGLE (DEG) =            ANGLE (DEG) =
         2.862                 -172.405

X COORD =                X COORD =
       -20.000                   12.000
Y COORD =                Y COORD =
         1.000                  -12.000

MAGNITUDE =              MAGNITUDE =
        20.025                   16.971
ANGLE (DEG) =            ANGLE (DEG) =
       177.138                  -45.000
```

IT'S THE LITTLE THINGS THAT COUNT

From time to time we like to pass along to you some true stories about the construction or reliability of Hewlett-Packard calculators that point out things not apparent when the machines are in use in a normal environment which is comfortable for the operators. The following two stories were submitted by Paul Dunn of the HP sales office in Glen Iris, Victoria, Australia.

You may recall reading in the newspaper recently about some disastrous floods in Brisbane, Australia. One customer there has a HP 9830A Calculator which ended up completely submerged. When the flood waters went down the equipment was dried out, and although the 9866A Printer would not function, the HP 9830 still worked just like new.

Jones, Flint & Pike, a surveying company in Brisbane, had ten HP pocket calculators in their basement. The entire room was flooded to a depth of 9 feet. When the water receded, the owners hosed all the mud and silt off the calculators, took the batteries out, dried them, and put them back together again. Nine out of the ten pocket calculators functioned and needed no repair; they are still performing.

These experiences give visibility to the type of quality built into HP calculators--quality that you take for granted or don't think about under normal conditions. If you have been surprised when your HP calculator worked after going through a flood, fire, or snowblower, write and tell us about it. Remember, it's the little things that count!