FLEER

1. Name of program: FLEER
2. Computer for which the program is designed: 32K IBM-704 with seven tape units and four logical drums *or* 32K Philco-2000 with fourteen tape units.
3. Nature of the problem solved: Two-dimensional diffusion equation in uniform triangular mesh geometry.
4. Method of solution: Because of the necessity of treating a special 120° periodic boundary condition, the inner or flux iteration is accomplished by accelerated Liebmann "bent" line relaxation. The outer boundary of a problem must be a rhombus located in the first quadrant of a coordinate system whose axes are inclined at 120°. The path of iterating any given line starts on the top of the rhombus and ends on the right hand side, bending on the main diagonal.
5. Restrictions on the complexity of the problems solved:

	IBM-704	Philco-2000
a. Number of groups	3	$\leqq 5$
b. Number of mesh points	14000	20000
c. Number of material regions	250	511

6. Typical running time. Without a good source guess, three group, 200 region problems take about 40 min per 1000 points on the IBM-704 and about 12 min per 1000 points on the Philco-2000. On either machine, the use of a good source guess from a similar problem will cut the time by 25 to 50%.
7. Unusual features: Both versions allow a special 120° periodic boundary condition to be applied to the left and bottom sides of a problem. The Philco-2000 version allows a doubly periodic boundary condition, i.e., 120° periodicity on top and right as well as left and bottom. The IBM-704 version cannot be depleted, but Philco-2000 FLEER is actually a part of the KARE System and thus shares all depletion, perturbation, and flux synthesis capabilities of that system. (See accompanying abstract.)
8. Present status: Both versions have been used extensively at KAPL; current usage is all on the Philco-2000. For further information, contact, J. L. Fletcher. Copies of the 704 version are available from the SHARE Secretary, Mr. Donald C. Cashman, SHARE Distribution Agency, 590 Madison Avenue, New York 22, New York. Copies of the Philco-2000 version are available from the TUG (Transac User Group) Executive Secretary, Mr. John C. W. Cadoo, Jr., Philco Corporation, 3900 Welsh Road, Willow Grove, Pennsylvania.
9. *References:* J. L. Fletcher, J. P. Jewett, and E. D. Reilly, Jr., FLEER: A two-dimensional triangular-mesh diffusion program for the IBM-704. KAPL-2086 (May 6, 1960). Also, see references under KARE.

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TRAM

1. Name of program: TRAM
2. Computer for which the program is designed: 32K Philco-2000 with seven tape units.
3. Nature of the problem solved: TRAM is a two- or three-dimensional neutron transport program for the Monte Carlo determination of spatial and spectral variations of the neutron population below 100 ev in hydrogen moderated assemblies. The computations are carried out by a nonbranching Monte Carlo method in which the principal random variables are obtained by a high-speed random address technique.
4. Method of solution: The input requirements of TRAM include a list of either number densities or masses and volumes for the elements of each material used in the problem. From this list, TRAM prepares tables of mean free paths and conditional probabilities for the collision processes for each of 32 energy groups. A one-group option may also be used.
   Source particles are automatically generated with a uniform distribution inside each source region and with a region dependent source rate specified as input. The source energy is stochastically determined by assuming that the particle has just been scattered by hydrogen with an incident energy of 100 ev.
   All elements except hydrogen scatter isotropically in the laboratory system without energy exchange. Five types of hydrogen scattering are used in various proportions in the 32 groups to provide a model for proton thermal motion and chemical binding which gives infinite medium spectra and diffusion lengths in agreement with measured values.
5. Restrictions on the complexity of the problem:
   a. Number of material regions $\leqq 100$
   b. Number of zones $\leqq 200$
   c. Number of surfaces $\leqq 200$
   d. Maximum source energy 100 ev
6. Typical running time: Thirty minutes to an hour or more depending on the complexity of the problem.
7. Unusual features: Geometrically, a TRAM problem is composed of up to 200 zones which may contain up to 100 different types of materials. Zones are bounded by surfaces (up to 200 are allowed) which may be either linear or sections of elliptic cylinders with axes parallel to the z-axis. Each surface may be designated as reflecting, transmitting, or trapping (incident particles are absorbed, counted in special trap registers, and removed from the game).
   Each TRAM problem consists of 25 repetitions, with different random numbers, of the same basic experiment, each run with the same number of particle histories. A final statistical edit will print estimates with confidence limits of the path-length accumulations and capture rates in each spatial zone of the problem. A special tracing mode allows the paths of individual particles to be followed in detail; this option is especially useful if difficulty is encountered in running a particular problem.
8. Present status: In production at KAPL. For further information, contact R. A. Pfeiffer. Copies of the program and of the report referenced below are available from the TUG Executive Secretary, Mr. John C. W. Cadoo, Jr., Philco Corporation, 3900 Welsh Road, Willow Grove, Pennsylvania.

9. *References:* R. A. Pfeiffer and W. W. Stone, TRAM for the Philco-2000. KAPL-M-RPC-1 (March 24, 1961).

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LOS ALAMOS LEAST SQUARES

1. Name of code: Los Alamos Least Squares
2. Computer for which code is designed: IBM 704
   Programming system: FORTRAN II
3. Nature of problem solved: Least squares fitting of linear or nonlinear functions in several independent variables. Thus, the program determines an estimate of A in the function $y = f(X; A)$ by means of minimizing the sum of squares. In the function, X is a vector of observed variables and A is a vector of parameters to be determined. In this context, a linear function is one whose partial derivatives with respect to the elements of A are all independent of A; a nonlinear function has at least one of the elements of A appearing in at least one of these partial derivatives. An example of a linear function is the usual linear regression model $y = XA = a_1x_1 + a_2x_2 + \cdots + a_kx_k$. A nonlinear function is the sum of exponentials model $y = a_1e^{a_2x} + a_3e^{a_4x} + \cdots + a_{k-1}e^{a_kx}$.
4. Method of solution: The iterative method of Gauss (sometimes called the Gauss-Seidel method) is used. The function is expanded with respect to A in a first-order Taylor's series about some point A_0. A vector of "corrections," say D, is obtained by multiple regression methods and a new estimate $A_1 = A_0 + D$ is obtained. The process is repeated until the vector D is "sufficiently small." The function and its derivatives with respect to the parameters are supplied to the program by the user by means of a subroutine.
5. Restrictions on complexity of problem: As originally conceived, the program was written for a 32K memory and would handle up to 500 data points, up to 5 independent variables, and up to 20 parameters. Different versions of the code are written for various memory sizes; 8K is usually sufficient, but it can be scaled to 4K. No restrictions have so far been encountered as to the nature or complexity of the function as long as no discontinuities exist in the function or its derivatives over the range of usefulness; i.e., the data must be physically significant, "well-behaved," and reasonably describe the function to be fitted. The Los Alamos 704 underflow is automatically set to zero, and the code does not check UV-OV conditions. Program and data are read on-line, with output going to BCD Tape 9.
6. Running time: Varies widely depending upon number of data points, parameters and independent variables; from 5 sec to 5 min. From 5 to 15 iterations are usually sufficient.
7. Unusual features: A damping factor is introduced to help control nonconvergent oscillations. Estimates of the standard deviation of all parameters are included with the solutions. Any (or all) parameters may be held at constant values. Arbitrary weighting of the observations y is permitted. The program package is "subroutine-ized" so that its various parts are easily modified or incorporated into other programs.
8. Present status: Several programs developed during the evolution of the present general code are currently operating at various Laboratories under such names as FRENIC, PEERLESS, and EXPO. 7090 Monitor versions are now being developed.
9. *Reference:* R. H. Moore and R. K. Ziegler, The solution of the general least squares problem with special reference to high-speed computers. Los Alamos Scientific Laboratory Report LA-2367 (October 15, 1959). This report contains a more complete set of references.

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9-RENUPAK (UNC-90-1)

1. Code designation: 9-RENUPAK (UNC-90-1)
2. Computer and programming system: Program is written in [F.A.P.] for the IBM-7090. A 32K core and ten tape units are required.
3. Problem solved: 9-RENUPAK treats the penetration of an infinite, homogeneous medium by neutrons from a point or plane isotropic source. The energy spectrum of the source must be continuous so that, for example, strictly monoenergetic source problems are excluded. The code output gives the neutron flux and current for both point and plane isotropic sources, as well as an integral over energy of the flux times an arbitrary response function, i.e., dose, activation, etc.
4. Method of solution: Computation is based on the moments method (*1–5*). After the moments are computed they are used to reconstruct the flux and current. The flux is assumed to consist of a linear combination of functions of given form, and constants in the expansion are adjusted so that the moments of the linear combination are the same as the computed moments of the flux.
5. Physics approximations: In the elastic slowing down treatment the neutron energy-angle relationship is taken into account properly. The code treats both elastic and inelastic scattering of neutrons. The inelastic scattering of neutrons is assumed to be isotropic in the laboratory system with a choice of several nuclear models in computing its energy dependence. In particular, the code allows for both discrete energy levels (when the levels are well separated) as well as a continuum of energy levels when the levels are very close. For heavy materials a statistical model is available.
6. Restrictions on complexity of problem: Maximum number of groups $\leqq 400$, isotopes $\leqq 5$, response functions $\leqq 16$. Only Gaussian and exponential fits available at present.
7. Typical running time: A typical calculation with 200 energy steps and 8 response functions, yielding both Gaussian and exponential fits for both point and plane source, takes about 12 min on the IBM-7090.