8. Status: Code is in use and available through United Nuclear Corp. Contact S. Preiser for additional information.
9. *References:*

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   2. J. CERTAINE AND J. BROOKS, Addition of inelastic scattering to the Univac moments calculations. NDA 2015-92 (December 1956).
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9-NIOBE (UNC-90-2)

1. Code designation: 9-NIOBE (UNC-90-2)
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. Nature of problem solved: 9-NIOBE solves the time independent multienergy neutron or gamma ray transport equation in a finite multilayered spherical configuration.
4. Method of solution: the computation can be broken down into two components, namely:
   (a) the slowing down treatment
   (b) the solution of the "one velocity" problem.

   In the elastic slowing down treatment, the neutron (or gamma ray) 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.

   The treatment of the solution of the "one velocity" Boltzmann equation is based on solving the integral form of the equation iteratively. Assuming a value for the angular flux, the "one velocity" equation is solved by integrating along the characteristics arising from a classical treatment of the first order partial differential equation. The process continues until two successive iterates agree to within a specified tolerance. Lagrange interpolation up to order fifteen is used on the angular variable, while all integrations over the angular variable are accomplished by Gaussian quadrature. Finally, an overrelaxation technique is employed, and convergence to the angular flux in a physical problem is expected.

   The cross section data required consists of the total and scattering cross sections, the Legendre coefficients of the differential scattering cross section (up to order 19), and appropriate data for inelastic scattering. The data are tabulated against energy, and the set of values required are computed by the code from these basic tabulations. The radiation source may be specified either as incident on the configuration or may be internally distributed.
5. Restrictions on complexity of problem: At each of a maximum of 200 radial points, 9-NIOBE calculates the angular neutron (or gamma) flux in a maximum of 16 directions, at a maximum of 200 energy values (spaced equally in increments in $\ln E$ for neutrons; spaced equally in wavelength for photons). At present, a maximum of five materials is permitted in each region, and up to fifty regions may be handled.
6. Typical running time: A typical problem having 85 radial meshpoints, 81 energy values, and 8 angular rays required $2\frac{1}{2}$ hr on the IBM-7090.
7. Status: Code is in use and available through UNC. Contact S. Preiser for additional information.
8. *References:*

   1. J. CERTAINE, A solution of the neutron transport equation—Part II. NDA-Univac Moment Calculations, NYO-6268 (1955).
   2. J. CERTAINE, Integral term for elastic scattering of particles. NDA 15C-12 (1953).
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   5. S. PREISER, G. RABINOWITZ, AND E. DEDUFOUR, A program for the numerical integration of the Boltzmann transport equation. NIOBE ARL Technical Report 60-314.
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