polynomials in the finite element method, then we have more nodes and the equation at node 5 involves terms at each node represented by • in Figure 10c. Because the equations are derived in different ways the finite element method is, however, easy to apply with the irregular geometries shown in earlier figures. In addition, certain types of boundary conditions are easily handled in finite element methods, particularly boundary conditions involving derivatives and/or free surfaces, whose location is to be determined.

SUMMARY

SINCE FINITE ELEMENT methods are being used increasingly by industry for design of structures, heat transfer, fluid flow, design of nuclear reactors, etc., it is important that modern students be exposed to them. It is not necessary that the engineer be familiar with the details of the method, but the engineer should know the general idea and be able to apply the method. The author has found students are quick to learn how to use finite element programs, and once experienced will always know what someone means when they say Finite Element Methods.

FURTHER INFORMATION

COMPARISONS OF finite element, collocation, and finite difference methods are given in Ref. (8). One-dimensional cases are emphasized since that allows the easiest description of the methods and details of applications. Two-dimensional problems are treated there as well as books by Huebner (7) and Chung (9). Huebner's book contains a simple finite element program for heat transfer problems. More elaborate programs are available (10). Applications to engineering design are widespread, and one concentrated source is the *International Journal of Numerical Methods in Engineering*. Probably there are published accounts of research applications of the finite element method in the journals related to your area of interest. □

REFERENCES

1. Bird, R. B., W. E. Stewart and E. N. Lightfoot, "Transport Phenomena," Wiley (1960).
2. Finlayson, B. A., "The Method of Weighted Residuals and Variational Principles," Academic Press (1972).
3. Carberry, J. J., "Chemical and Catalytic Reaction Engineering," McGraw-Hill (1976).
4. Finlayson, B. A., "Orthogonal Collocating in Chemical Reaction Engineering," Cat. Rev.-Sci. Eng. *10*, 69-138 (1974).
5. Paterson, W. R. and D. L. Cresswell, "A simple method for the calculation of effectiveness factors," Chem. Eng. Sci. *26*, 605-616 (1971).
6. Hood, P., "Frontal Solution Program for Unsymmetric Matrices," Int. J. Num. Methods. Eng. *10*, 379-399 (1976); *11*, 1055, 1202 (1977).
7. Huebner, K. H., "The Finite Element Method for Engineers," Wiley (1975).
8. Finlayson, B. A., "Nonlinear Analysis in Chemical Engineering," McGraw-Hill (1980).
9. Chung, T. J., "Finite Element Analysis in Fluid Dynamics," McGraw-Hill (1978).
10. Program DOT available from Professor E. L. Wilson, Department of Civil Engineering, University of California, Berkeley, California 94720.

ChE letters

FOREIGN STUDY PROGRAM

Dear Sir:

We read with interest about the successful Study-Travel Program at Virginia Tech (Summer 1980 issue).

I would like to briefly mention two intensive foreign study programs which are open to selected Chemical Engineering undergraduates at Case Western Reserve. They may also serve as examples for other Departments who wish to initiate such programs.

Each year since 1978, three of our undergraduates have spent their junior year at the University of Edinburgh. There they are regular full time students in the third year Chemical Engineering program. The students normally live in university student housing and can participate in the usual range of student activities. Full academic transfer credit for a years work is granted upon successful completion of the third year course at Edinburgh. This arrangement has been extremely successful, primarily due to the excellent and continued cooperation of the Edinburgh faculty. The experiences of the students have been uniformly good and there have been minimal academic re-entry problems after returning to Case for their senior year.

We also participate, with Iowa State University and Georgia Tech, in a summer laboratory course at University College London. This very well run program lasts for approximately one month and, in addition to the intensive laboratory course, includes a one week bus tour of various British chemical industries. Credit for our Unit Operations Lab is given upon completion of the course. Part of the reason for the success of the program is the dedicated work of the faculty representatives from Iowa State and Georgia Tech that accompany the students.

Overseas study has been an area in which we in engineering education have lagged behind our colleagues in the liberal arts. Part of the reason has been the necessity of meshing requirements from two highly structured curricula. Despite these difficulties, the remarkable benefits to the students involved make the effort worthwhile. More programs of this type should surely be offered.

Sincerely yours,
John C. Angus
Case Western Reserve University