City and Guilds of London Institute
INCORPORATED BY ROYAL CHARTER · FOUNDED IN 1878

319
Certificate for Computer Personnel

320
Advanced Certificate for Computer Personnel

For Examinations in 1968

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76 Portland Place, London W.1

Advisory Committee for the Training of Computer Personnel

List of Members – February 1967

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CERTIFICATE FOR COMPUTER PERSONNEL

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1. Introduction

A two-stage scheme for courses and related examinations has been adopted by the Institute on the recommendation of its Advisory Committee for Computer Personnel. It has been designed to meet the needs of those working with digital computers as computer room personnel, data handling personnel, junior programmers and coders, and, as a higher level, of those exercising a measure of responsibility for operating, data preparation, programming and technical programming advice.

The first stage of the scheme, Certificate for Computer Personnel (319), is intended to provide a study of the basic techniques of programming, coding and operation, together with an appreciation of the relevant mathematics and statistics. It is based upon a knowledge of the uses and potentialities of computers.

The second stage, Advanced Certificate for Computer Personnel (320), is intended to provide a more advanced study of computer techniques, especially programming. It is designed for students who will normally have already completed the course at Certificate level and who will be likely to have, or to be preparing for, some responsibility for data processing work. (Details of this second stage appear later in this pamphlet.)

Owing to the rapid advances in computer technology and its applications, this scheme must constantly be kept under review. A revision of the first stage (319), together with the Mnemonic Code, has therefore been undertaken and the new scheme will be introduced shortly.

2. Curriculum

Courses at Certificate level should include the following curriculum:

A: Computers, Theory and Applications.
B: Equipment, Principles and Practice.
C: Computing Methods.
D: Mathematics and Statistics.
E: Related Studies.

In addition, courses should, wherever possible, include general studies (see below).

3. Course of Study

3.1 The scheme has been designed on the assumption that a minimum of 480 hours will be available for theoretical and practical work on the syllabuses. In addition, it is recommended that there should be a further allocation of time for general studies (see 12 below).

The organization of courses will vary according to the requirements of the locality and it is strongly recommended that as flexible an approach as possible should be adopted. No one particular type of course may be entirely suitable and principals will no doubt wish to consider all possibilities and combinations of part-time day, block release, and full-time courses. For all courses it is essential that there are adequate arrangements for both theoretical and practical course work.

For part-time day release courses, the minimum of 480 hours should be available over the two years. In the case of three-year courses, a minimum of 720 hours should be available.

For block release and full-time courses it will be necessary to ensure that students gain the necessary practical experience in addition to their course work and a minimum of 720 hours is recommended for the course.

3.2 The selection of students for courses is entirely at the discretion of the college authorities. It is however suggested that at Certificate level students should have satisfactorily completed a five-year course* at secondary school, including Mathematics at Ordinary level in the General Certificate of Education (or Grade I level in the Certificate of Secondary Education) for entry to a two-year course. For those students without Mathematics at Ordinary level in the General Certificate of Education, but who have satisfactorily completed a four-year course† at secondary school including Mathematics, it is suggested that a three-year course will be necessary. Separate syllabuses have not been prepared for the two- and three-year courses, but suggestions on their treatment are given in Explanatory Notes below.

4. Approval of Courses

4.1 Courses under this scheme require approval by the Institute. Principals of colleges should apply to the Institute for approval of the course not less than 6 months before it is due to start.
Courses will not be approved unless there are adequate facilities for the theoretical and practical work. Details of the suggested minimum equipment required may be obtained from the Institute (see 10 below).
Where courses are offered outside the British Isles they must be conducted at a technical college or similar establishment provided by a Government Education Department or by some other organization which agrees to open the college to inspection by, or on behalf of, the Institute and by the relevant Government Education Department.

4.2 In the case of courses in the British Isles, applications should be made on Form APP, and in the case of courses outside the British Isles, on Form F2045. Copies of these forms may be obtained from the City and Guilds of London Institute, 76 Portland Place, London, W.1.

5. Notification of Courses

Centres proposing to submit entries for the examination should notify the Institute of their courses of study annually on Form 12.

6. Examination

6.1 The examination for the Certificate for Computer Personnel offered annually by the Institute will comprise:
319/1/01—written paper (3 hours)—
319/1/02—written paper (3 hours)—covering all sections of the syllabuses.
319/1/03—written paper (3 hours)—on problem analysis and programming.
In the examination, questions involving coding will be confined to the special mnemonic code. Copies of the code will be available to candidates.
There will be no practical examination, but candidates will be required to carry out certain practical work during the course (see syllabuses below). Written records of this practical work must be kept and a selection of these records may be called for assessment by the Institute each year and may be taken into account when determining the results in the examination.

6.2 The general regulations applicable to the conduct of these examinations are given in the Institute's Form 1—General Regulations and Calendar.

† Three year course in Scotland.
*Four-year course in Scotland.

7 Entry to Examination

7.1 Internal Candidates

Candidates who will have satisfactorily completed an approved course of study must make their entries through the college authorities by the prescribed date (see Tables A and B in the Institute's General Regulations—Form 1).

7.2 External Candidates

Candidates who have valid reasons for not attending an approved course of study may apply to the Institute for permission to take this examination. Applications must be made by 1st February in the year of examination and forms (Form CP/X) for this purpose may be obtained from the Institute.
Permission will be granted only in exceptional cases where there are valid reasons for not having attended an approved course, and where the Institute is satisfied as to the candidate's experience and preparation for the examination. Candidates to whom it has been granted must make arrangements with the Institute's local secretary at their nearest examination centre for the necessary accommodation and for their entries to be sent to the Institute by the prescribed date (see Tables A and B in the Institute's General Regulations—Form 1).

7.3 Local Secretaries will be required on Form CS (i) to certify that all internal candidates entered will have completed the college course, including the necessary practical work, and (ii) to give a list of all external candidates entered.

8. Candidates Overseas

8.1 Internal Candidates

Candidates who will have satisfactorily completed an approved course of study (see 4 above) will be accepted for examination at centres overseas under the same conditions as in 7 above.

8.2 External Candidates

Candidates who have not attended an approved course of study may not enter for this examination at centres overseas.

9. Award of Certificates

Results in the examination as a whole will be issued in four classes, and for the individual parts of the examination in eight grades. The relationship between grades and classes is:

Pass with Distinction	— Grades 1 and 2
Pass with Credit	— Grades 3 and 4
Pass	— Grades 5 and 6
Fail	— Grades 7 and 8.

Each candidate will receive a record of performance giving his result in terms of class and grades. Successful candidates will receive the Certificate for Computer Personnel showing the class of their result in the examination as a whole.

10. List of Equipment

A list of equipment indicating the minimum requirements for courses at Certificate level has been prepared by the Institute. The list may be obtained on application to the City and Guilds of London Institute, 76 Portland Place, London, W.1. Applications should state the subject (319).

11. List of Textbooks and Works of Reference

A list of textbooks and works of reference has been prepared by the Institute for the information of those interested in the scheme at Certificate level. The list is not

exhaustive and it is emphasized that the Institute's examinations are not set on any specified books.
The list may be obtained on application to the City and Guilds of London Institute, 76 Portland Place, London, W.1. Applications should state the subject (319) and be accompanied by the appropriate postage.

12. General Studies

12.1 Courses under this scheme should, wherever possible, include general studies. These are particularly important to computer personnel, who must be able to express themselves clearly and logically. In addition, for those whose work may at some time involve responsibility for the work of others, the development of broad interests and sympathies is important. The allocation of time for the teaching of English and general studies should be in addition to that for work on the technical and related studies (see 3 above).
12.2 It is suggested that the work might include oral, visual and written communication (including the use of the English language). Also, in view of the wide and increasing applications of the computer, the social impact of computers might be included, together with work on topics such as those covered in the syllabus on Related Studies.
12.3 The Institute will, however, not examine these subjects or require completion of a course in them as a condition of eligibility for the examination for the Certificate for Computer Personnel.

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Syllabuses

Notes:

(*a*) Use of terms should be in accordance with the B.S. 3527.
(*b*) Use of flowchart symbols should be in accordance with B.S. (shortly to be published).
(*c*) Explanatory notes on the syllabuses appear later in the pamphlet.
(*d*) The special introductory mnemonic code appears later in this pamphlet.

A. COMPUTERS, THEORY AND APPLICATIONS

Notes:

(i) Practical work must include programming of simple applications. Attention should be given to: preparation of overall and detailed flowcharts; preparation of test cases by program and all auxiliary programs to test main programs; planning programs in block structure to facilitate testing; use of tracing, monitoring and similar techniques in program development.

(ii) Students will be expected to use both the special introductory mnemonic code and, for applications programming, any other single-address code, multi-address code or autocode available at the college.

(iii) In the examination, questions involving coding will be confined to the special mnemonic code, copies of which will be available to candidates. Questions may also be set which require a general knowledge of multi-address systems.

A.1 Introduction. Evolution of computing machines, range of applications, data representation, fundamental concepts of a digital computer.

A.2 Problem analysis and basic programming:
(*a*) problem analysis;
(*b*) construction of flowcharts;
(*c*) coding (see notes (ii) and (iii));
(*d*) program efficiency;
(*e*) program and data preparation and verification;
(*f*) storage allocation;
(*g*) input and output routines;
(*h*) program development, testing and checking;
(*i*) documentation of programs.

A.3 Further programming, with applications (see notes (ii) and (iii)):
(*a*) use of subroutines, library routines, diagnostic aids;
(*b*) programming of applications derived from all sections of the syllabuses.

A.4 "Software" developments (introduction):
(*a*) machine languages, including multi-address instructions;
(*b*) assembly languages;
(*c*) compilers;
(*d*) programming languages for business and scientific applications.

B. EQUIPMENT, PRINCIPLES AND PRACTICE

Note: Practical work must include the use of punched card and paper tape equipment for the preparation of data and programs and, wherever possible, the operational handling of on-line peripheral equipment, including (i) continuous stationery, (ii) punched card files, (iii) paper tape, and (iv) magnetic tape.

B.1 Basic parts of a computing system; input, control, immediate access stores, backing stores, random access stores, arithmetic unit, index registers, output.

B.2 Detailed study of equipment for, and methods of use (including handling and storage) of:

(*a*) punched cards; punching, verifying, listing and sorting;

(*b*) punched paper tape; punching, verifying, correcting, splicing and reproducing; five, six, seven and eight channel tape;

(*c*) magnetic tape; labelling, blocking data; methods of dealing with data of variable length; use of dumping and re-starting; use of control totals, "hash" totals, check sums;

(*d*) printed output.

B.3 Coded representation of program and data. Methods of error detection and correction.

B.4 Effect of errors on computer running. Data errors, program errors, machine errors. Use of monitoring equipment.

B.5 Office machinery producing punched paper tape or cards as a preliminary to processing by computer.

C. COMPUTING METHODS

Note: Practical work should refer especially to the methods in sections C.3, C.4 and C.5.

C.1 Use of slide rule, of desk calculating machines and of standard six-figure (shorter), statistical and computation tables.

C.2 Computer arithmetic. Binary, octal and decimal representation of numbers. Methods of conversion. Fixed and floating point operations. Approximate numbers. Absolute and relative errors. Accumulation of error. Errors of fixed and floating point operations. Overflow and underflow.

C.3 Typical methods of handling financial, industrial and statistical data in bulk.

C.4 Methods of sorting, collating, merging lists or files.

C.5 Construction and use of tables. Simple tabulation. Methods of checking, including use of finite differences.

C.6 Solution of linear simultaneous equations. Gaussian and Jordan elimination. Simple matrix methods. Illustration of ill-conditioning.

C.7 Evaluation of polynomials. Division by linear factors. Real roots of algebraic equations. Graphical approximation. Iterative methods* using $x = f(x)$. Evaluation of square roots and reciprocals.

C.8 Method* of least squares. Fitting of points by straight line and parabola.

* Knowledge of the calculus for these methods will *not* be required in the examination.

D. MATHEMATICS AND STATISTICS

Note: Technical skill in mathematical manipulation and technique is not required. The aim should be to develop an understanding of these underlying concepts. In the examination, candidates will be expected to apply these concepts in elementary situations.

D.1 Logical arithmetic. Logical "and", "or", "non-equivalence". Simple applications.

D.2 Linear algebra. Simultaneous linear equations. Matrices; rules of addition and multiplication, including $(m \times n)$ matrices. Linear equations expressed in matrix notation; formal solution by means of matrix inversion. Simultaneous linear inequalities. Geometrical interpretation. Introduction to Simplex method. Applications (e.g., equations of supply and demand for a product).

D.3 Simple functions. Polynomials; sine, cosine and tangent. Series. Arithmetic and geometric series. Binomial theorem for positive integral index. Series representation of sine and cosine. Indices. Logarithms. Introduction to logarithmic and exponential functions.

D.4 Non-linear equations. Quadratic and cubic equations.

D.5 Introduction to calculus. Idea of limit. Derivative of a function. Derivatives of simple functions from first principles. Application to maxima and minima. Integration as a means of summation. Trapezoidal rule and Simpson's rule.

D.6 Statistics. Terminology. Ideas of population and sampling. Collection of data. Frequency distributions. First and second moments (statistical means and standard deviation). Elements of probability. Use of binomial distribution.

E. RELATED STUDIES

Note: The following syllabus is intended as a general background to the other syllabuses. In the examination at Certificate level there will be no questions set on it, but its subject matter will be used to provide material for realistic situations in questions on the other syllabuses.

A brief survey of the following:

(*a*) Information. Financial—accounting, costing, wages, and salaries; management—planning, forecasting, co-ordination, control, decision-taking; methods of preparation, recording, analysis, transmission, and processing—manual, mechanical, electronic.

(*b*) Development of computers. Abacus and other computing tools; desk calculators; punched-card machines in computation; binary representation of information and electronic devices in computation; internally stored programs; early machines; computers and associated equipment currently available—large and small digital, analog and hybrid; data processing configurations; recent developments.

(*c*) Present-day applications of computers in the national life, e.g., manufacture, distribution, finance, research and development, government and defence. The following are some typical examples—advertising, banking, communication satellite control, data reduction, design evaluation, early warning systems, insurance, language analysis, machine tool control, market research, operational research, process control, production control, sales invoicing, stock control and purchasing, systems simulation, weather forecasting, weapon control.

EXPLANATORY NOTES

1. It is expected that most students attending courses under this scheme will be employed in a computer environment where they will be trained in certain computer skills. The organizations in which they are employed may be concerned with one or more of a variety of scientific, industrial, commercial or administrative applications of computers. The purpose of the scheme at this level is twofold: (i) to enable the students to carry out their current duties with greater understanding and efficiency, and (ii) to prepare those who are capable for a more advanced study of computer techniques, especially programming; this is provided by the second stage of the scheme, Advanced Certificate for Computer Personnel (details of which appear later in this pamphlet).

2. The scheme at Certificate level includes a study of the general properties and potentialities of the machines with which the students will be concerned, together with a survey of the many factors which have contributed to the use and development of the computer. The syllabuses in "Computers, Theory and Applications", and in "Equipment, Principles and Practice", form the core of the curriculum. The importance of theoretical and practical work on these two syllabuses cannot be overemphasized. In practical work, the aim should be to demonstrate, and to instil into students the best principles of computer room discipline, both in the handling and in the treatment of equipment and stationery. The supporting syllabuses in "Computing Methods" and in "Mathematics and Statistics" are designed to provide a grounding in those basic concepts in common use in computer installations and desirable also as a basis for more advanced studies of computer techniques. It is intended that these subjects should be developed in parallel and closely linked with work on the syllabuses in "Computers, Theory and Applications" and in "Equipment, Principles and Practice", as well as with the background studies covered in the syllabus in "Related Studies".

3. On two-year part-time courses (for students who have studied Mathematics to Ordinary level in the General Certificate of Education, or the equivalent), it is suggested that the following might form the basis for the allocation of teaching time over the two years:

	Hours
A—Computers, Theory and Applications	110
B—Equipment, Principles and Practice	40
Practical work for A and B	110
C—Computing Methods	75
D—Mathematics and Statistics	75
E—Related Studies	70
General Studies	up to 180

In planning the scheme, concurrent development of each subject over the two years has been assumed with the exception of work on "Equipment, Principles and Practice" which should as far as possible be carried out in the first year.

4. Where three-year part-time courses are provided (for example, for students who have not studied Mathematics to Ordinary level in the General Certificate of Education or Grade I level in the Certificate of Secondary Education, or for other sound educational reasons), no detailed suggestions as to the allocation of teaching time are made as it is considered that this may vary widely. However, it is probable that a greater allocation may be required for work on "Computing Methods" and on "Mathematics and Statistics".

5. Detailed notes on the syllabuses are given below, but it should be emphasized that the success of courses will depend very largely on effective inter-relation of the

syllabuses. It is essential that teachers collaborate closely to ensure that in the teaching of each syllabus there is appropriate and adequate cross-reference to the others.

Computers, Theory and Applications

6. The theoretical and practical work on this syllabus will represent a major part of the course. As the syllabus indicates, the emphasis is primarily on the logical principles and methods of use of stored-program computers, and on the significance of "software" rather than "hardware" in the successful application of computers.

7. It is important at this stage to provide a simple, overall appreciation of what is involved in preparing and presenting a problem for solution by a digital computer. There should be adequate examples and practical work on all stages of the process, from the initial analysis and flow-charting, through annotation of the computer program to the final specification, so that the methods adopted may be clearly understood by someone other than the author of the program.

8. At this stage, students should be introduced to one programming language and one machine oriented code. The objective in teaching the machine code should be to illustrate some of the computer facilities which are implicit in the use of programming languages and "executive" routines. The student will thus be able to appreciate the basic elements of program construction, e.g. jumps, cycles, address modification, and the transfer of information both between peripherals and the central processor and within the computer. A special mnemonic code has been designed by the Institute for this purpose and also for use in the examination at Certificate level; details of this code appear later in this pamphlet. For the implementation of this code, colleges should ensure that a compiler suitable for the machine to be used is available.

9. It should be noted, however, that for application programming, students will be required to use other codes (e.g. multi-address code, autocode) and work on them should be included as indicated in the syllabuses. It is suggested that full use should be made of the programming language used with the computer at the college or to which the students have access. As early in the course as possible some experience in applying a user oriented autocode is also desirable, although not all the available facilities in such a language need to be taught at Certificate level.

10. The problems selected for programming should be simple and well defined; they must be suitable for the potential operator as well as the potential programmer. It is essential that the programming language has data processing facilities so that students are not limited to problems using only mathematical formulae.

11. In devising programming examples, it is recommended that teachers make full use of relevant material in the other syllabuses. whether "Mathematics and Statistics", "Computing Methods", or "Related Studies". Examples and simple case studies should be drawn from everyday experience and should reflect as wide a variety of applications as possible. They should include logical and non-numerical as well as numerical problems. Every student should have the earliest possible opportunity of running a program on a computer.

12. The section of the syllabus on softwave developments (A.4) is meant to be introductory, and should be treated briefly and descriptively, preferably during the final year of the course. Compilers for the special mnemonic code may be of a sufficiently simple nature to serve as a useful introduction to the construction of compilers at Advanced Certificate level.

Equipment, Principles and Practice

13. This syllabus is designed to provide the student with a broad picture of an integrated data processing system, leading to the actual use of a system. It will be

essential to make clear the way in which the system controls the input and output of information and the manner in which the program is executed.

14. It is important that the student has a clear understanding of binary arithmetic so that the description of a typical machine language in binary or modified binary notation may be used. Emphasis should be laid on the ability of the machine to process both numeric and alpha-numeric data.

15. When the concepts of coding have been adequately practised and understood, the methods of getting information into the central processor should be introduced. Various modes of input and output should be described and it is suggested that an actual installation might be taken as an example; students should have the opportunity of studying such a system in detail and visits to actual installations would be of advantage. The problems of matching the slower peripherals, such as electro-mechanical printing and punching equipment, to the speed of computer electronics should be discussed.

16. The central processor should be described in detail and emphasis laid on the presence of both slow and fast access stores, so that the philosophy and organisation of such arrangements may be described. It may be found helpful to use simple electronic circuits to demonstrate the movement of data within the processor.

17. Throughout the course, emphasis should be laid on the methods used for ensuring accuracy of input data and on ensuring the efficient use of machine time.

18. The study of computer systems cannot "come to life" unless students have an opportunity to write their own programs and to present them to a machine. Students should have the earliest possible opportunity of using the equipment, and practical work is of the greatest importance.

Computing Methods

19. This syllabus, while standing in its own right, provides a bridge between that in "Mathematics and Statistics" and those in "Computers, Theory and Applications" and in "Equipment, Principles and Practice". It should not, therefore, be taught in isolation, and in particular the introduction of the necessary mathematical concepts will be essential.

20. Every opportunity should be taken to relate work on this syllabus to real-life applications which will arise from work on "Computers, Theory and Applications" and on "Equipment, Principles and Practice". Where these techniques are equally applicable to work in more than one field, due emphasis should be given to their range of applications in commercial, industrial, scientific and administrative work.

Mathematics and Statistics

21. The purpose of this syllabus is to introduce the basic mathematical ideas thought relevant to all fields of computer applications. The concepts and ideas involved will become increasingly important to computer users concerned with both commercial and industrial applications and are therefore included in the scheme. Skill in mathematical manipulation and technique is not expected from students but an understanding of the underlying concepts will be of value to all students,whatever their work. The examination will reflect this approach, and candidates will be expected to apply the concepts of this syllabus in elementary situations, but will not be required to carry out involved manipulations in the course of problem solving. Throughout the teaching on this syllabus the relevance of these concepts to real-life situations should continually be stressed and examples should be chosen accordingly.

22. Considerable importance is attached to the introduction of logical arithmetic, which should occur early in the course. The use of logical operations should be

illustrated by problems of the "cannibals and missionaries" type, and students should be encouraged to formulate and solve puzzles of this kind.

23. It is suggested that sections D.1, D.2, D.3, and D.6 should all be introduced, though not necessarily completed, during the first year of the course. The treatment of matrices and the introduction of calculus may with advantage be deferred to the last year; a liberal use of graphs is recommended.

24. The geometrical interpretation of linear equations should be used to illustrate situations in which ill-conditioning is likely. Linear inequalities should be discussed with a view to their use later in linear programming problems; a geometrical interpretation may again be found helpful.

25. In discussing the properties of quantities which can be represented by matrices it will be useful to make comparison with more general arrays such as may be considered, for instance, in section C.3 of the syllabus in "Computing Methods". Close co-ordination between the teaching of "Mathematics and Statistics" and the introduction of "Computing Methods" is clearly desirable.

Related Studies

26. The computer is a complex tool now used in business management, industrial planning and control, scientific research, and other fields. The scheme at Certificate level has been designed to provide a basic education for those who will, one day, be largely responsible for the operation and application of computer techniques. It would not, therefore, be complete without some study of the many factors which have contributed to the development of these tools, and the conditions in which they are applied. This syllabus is designed as a basis for such a study, and in addition, an understanding of it will be most important as a foundation for the more detailed studies at Advanced Certificate level.

27. The history of the design and development of computing tools leading to a survey of present-day equipment and its uses, with some indication of future possibilities, will capture the imagination of the student. The sections on "Development of computers" and "Present-day applications of computers in the national life" have been designed to provide a useful and realistic background to work on the other syllabuses, and should preferably be covered in the early part of the course. The aim should be to show, against a background of the organisation of the various sectors of industry, trade, finance, research and development, government, and defence, how and why computers have been put to such different uses and how they are going to play such an important part in our daily lives.

28. The handling and communication of information is a basic activity common to all sectors of our national life. Its efficient execution is essential to the economic progress of the nation and can be assisted and improved by the application of computer techniques. The section on "Information" provides for a survey of the various methods for the preparation, recording, analysis, transmission and processing of information; the importance of logical thought and expression of ideas should be emphasized in this connection. The detailed handling and communication of data should be covered in the teaching of the other syllabuses.

29. In the examination at Certificate level, questions will not be set on this syllabus. Its subject matter, however, will be used to provide material for realistic situations in questions on the other syllabuses.

30. The subject matter of this scheme is one of the major tools of the modern scientific and technological revolution. Following the lead given by the Ministry of Education in its report on "General Studies in Technical Colleges" (pp. 10, 11), this syllabus has been designed to lead into a course of English and general studies which could be of value to students from other courses.

MNEMONIC CODE

1. Machine Requirements

The minimum machine configuration necessary for implementation of the mnemonic code consists of a central processing unit, one reader (paper tape or punched card) and one punch (paper tape or punched card). The central processing unit has a control register, an accumulator and a store.

1.1 Store

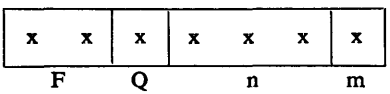
The store consists of 1000 locations, addressed consecutively from 0, 1, 2, 3,.....999. With the exception of location 0, each location can hold either one number or one instruction. The first ten locations have "special" applications.

1.1.1 Numbers

Each number will be held to a precision of 7 decimal digits and as far as the student is concerned, the number may be integral, fractional or mixed. The student will consider it a "number machine", and although it will undoubtedly operate in floating point to a precision determined by the implementor, the student will not initially be required to distinguish between fixed and floating point numbers.

1.1.2 Instructions

The instruction word format is:



F The function part (2 decimal digits) specifies the operation which takes place between the specified operand in the given address and the contents of the accumulator. In the written form of the instruction (*q.v.*), the function part will always be 3 or 4 letters.

Q A query digit, which if omitted causes no further action, if present allows tracing of the program. The operation of this digit is left to the discretion of the implementor.

n The address part refers to any one location in the range 0,.....999.

m The modifier digit refers to any one index register in the range 0, 1,.....9.

1.1.3 Special Locations

The first ten locations in the store are reserved in the following way:

0 The contents of location 0 will always be zero; hence if no modifier is specified in the instruction, modification by the (0) will take place. 0 is the only location into which information cannot be transferred.

1 This is the address of the accumulator A.

2, 3 } By convention, these are the normal index registers.

4 : 9 } These are additional index registers if provided by implementors. In the case of the instruction JSR (*q.v.*) the link will be held in location 4.

1.2 Control Register C

The control register is automatically updated by one during execution of an instruction, ready for extraction of the following instruction. Breaks in this sequence only occur when jump instructions are executed.

1.3 Input/Output Equipment

Control of input/output equipment will be determined by individual implementors; for example, the columns on a card which are to be available for data, reference numbers, etc.

1.4 Off-line Equipment

Programs will be prepared, in general, on an off-line reproducer set. Each instruction will occupy one line, will be opened by its commencing symbol and be terminated by ⊿ (space) or crlf. The minimum character set which will have to be available for both program preparation and for off-line printing of results is as follows:

Letters: A, B, C, ...Z

Digits: 0, 1, 2, ...9

Control symbols: crlf, letter shift, figure shift, space, erase.

Other symbols: ( ) + − . ,

2. Minimum Instruction Set

Numeric Function	*Mnemonic Instruction*		*Operation*	*Remarks*
00	LDA	n, m	(n+(m))→A	Load operand into cleared accumulator.
01	ADD	n, m	(A)+(n+(m))→A	Add operand.
02	SUB	n, m	(A)−(n+(m))→A	Subtract operand.
03	MLT	n, m	(A)×(n+(m))→A	Multiply by operand.
04	DIV	n, m	(A) / (n+(m))→A	Divide by operand.
10	LDAN	n	n→A	Load integer n into cleared accumulator.
11	ADDN	n	(A)+n→A	Add integer.
12	SUBN	n	(A)−n→A	Subtract integer.
13	MLTN	n	(A)×n→A	Multiply by integer.
14	DIVN	n	(A) / n→A	Divide by integer.
20	STA	n, m	(A)→n+(m)	Store (A) without clearing the accumulator.
30	JUN	n, m	n+(m)→C	Jump unconditionally.
31	JGR	n, m	If (A)⩾0, n+(m)→C	Jump if (A)⩾0
32	JEQ	n, m	If (A)=0, n+(m)→C	Jump if (A)=0
33	JSR	n, m	Link →4; n+(m)→C	Set link and jump.
34	JST	n, m	Wait; n+(m)→C	Wait; jump when start button operated.
40	SQT	n	√(A)→A	If (A) <0, jump to n.
41	EXP	n	exp(A)→A	If (A) too large, jump to n.
42	LGN	n	ln(A)→A	If (A) <0, jump to n.
43	SIN	n	sin(A)→A	(A) in radians.
44	COS	n	cos(A)→A	(A) in radians.
45	ARC	n	arctan(A)→A	
46	ENT	n	entier(A)→A	Integral part of (A)→A.
50	RCT	n, m	character→n+(m)	Read single character from tape.
51	PCT	n, m	(n+(m))→tape	Punch single character on tape.

Numeric Function	*Mnemonic Instruction*		*Operation*	*Remarks*
52	RNT	n, m	number→A	Read number from tape to accumulator. Jump to n+(m) if error in the number.
53	PNT	n, m	(A)→tape	Punch signed number in accumulator on to tape with n integral and m fractional digits.
54	PNL			Punch the characters for new-line.
60	RCC	n, m	characters→n+(m)	Read characters from card.
61	PCC	n, m	(n+(m))→card	Punch characters on card.
62	RNC	n, m	number→A	Read number from card to accumulator. Jump to n+(m) if error in the number.
63	PNC	n, m	(A)→card	Punch signed number in accumulator on to card with n integral and m fractional digits.

3. **Input Directives**

(STORE n′)	Commence storing program sequentially from location n′.
(WAIT)	Temporary stop during input for change of tapes.
(EXECUTE n′)	Commence execution of program at instruction in location n′.
(TITLE) "String"	The alpha-numeric string immediately following the right bracket will be copied on to output tape.

4. **Notes Concerning Instructions**

The written form of each instruction will be, in general, as follows:
LDA n, m where L is the opening symbol of the instruction, n is the address and m the modifier address.

If there is no modification necessary, the ", m" may be omitted and modification by location 0 will then be implied. Specimen instructions are:
LDA 100 (100) unmodified→A
MLT 200, 3 (A)×(200 modified by (3))→A

The comma is used to separate the addresses n and m.

Note that n should precede m.

The addition of Q(query) to any instruction will cause the query digit to be set during input. Then on execution, when a query digit is encountered, the address of that instruction together with the contents of the accumulator after execution will be monitored giving a program trace. The operations associated with Q will be left to the discretion of the implementor as it has no direct bearing on the use of the code during examinations.

4.1 **Instructions 00 to 04**

All instructions leave the specified store location unchanged.

4.2 **Instructions 10 to 14**

m should be omitted from this group of instructions, which are considered optional. The addition of N to the function letters will cause the address part n to be considered as a positive integer in the range $0 \leqslant n \leqslant 999$.

4.3 **Instruction 20**

This instruction will overwrite any previous contents of the specified location.

4.4 **Instructions 30 to 34**

It is expected that in general, m will be zero. It should be noted that all these instructions cause jumps to absolute addresses; there is no symbolic addressing. As the implementation of this scheme will be in floating point, the selection of a suitable "zero" for the JEQ instruction is left to the implementor.

JSR, which is intended only for subroutine entry, will set its link in 4. Hence exit from the subroutine will always be via (4). It is not expected that students will "nest" subroutines, but if the need arises, they can extract (4) and put to safety elsewhere. The link will always be the current store address plus one, i.e., the one following the JSR instruction.

4.5 **Instructions 40 to 46**

These should be considered as very powerful machine instructions, which calculate the "standard" functions. The addresses are used for escape routes if the arguments are not within the prescribed range. In general these will be at the discretion of the implementor.

4.6 **Instructions 50 to 54**

The characters will be stored as their "decimal values" in the least significant end of the specified store locations, together with their appropriate shift marker. The organization of these instructions, when dealing with checking or non-checking codes, 5, 6 or 7 track tape, etc., will be left to the implementor.

Numbers should be opened by a decimal digit or sign, have any normal format and be terminated by space or crlf. Each number as punched should contain no more than 7 decimal digits.

4.7 **Instructions 60 to 63**

RCC will read a complete card into a "buffer area" determined by its starting address n. The characters will all be placed into the least significant ends of these locations. The card format and number of characters read will be left to the implementor.

PCC will punch a card from the buffer area specified by the address n. It is expected that m will be zero in both these cases and some installations may choose to have n predetermined.

Numbers will be dealt with in the same way as the corresponding tape instructions although the columns holding the number will be at the implementor's discretion.

5. **Notes Concerning Directives**

The purpose of the directives is to inform the assembler or compiler that it should perform certain functions immediately, i.e., during the input process. They are intended to be self-explanatory although their specific functions will depend on whether an assembler or compiler is being written. This choice is left to the implementor.

Each directive is enclosed in parentheses. The "string" following (TITLE) must commence and terminate with crlf, and the whole of that string will then be copied on to the output tape, preceding any results. Care should be taken not to exceed one line of printing.

6. **Input of Numbers with Program**

Numbers may be stored together with instructions as long as each number is headed by a + or − sign. They may be assembled from any of the usual ways of writing numbers, e.g.

+123
−0.456
+7.89

ADVANCED CERTIFICATE FOR COMPUTER PERSONNEL

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1. Introduction

1.1 A two-stage scheme for courses and related examinations for computer personnel has been adopted by the Institute on the recommendation of its Advisory Committee for Computer Personnel. It has been designed to meet the needs of those working with digital computers as computer room personnel, data handling personnel, junior programmers and coders, and, at a higher level, of those exercising a measure of responsibility for operating, data preparation, programming and technical programming advice.

The first stage of the scheme, for the Certificate for Computer Personnel (319), is intended to provide a study of the basic techniques of programming, coding and operation, together with an appreciation of the relevant mathematics and statistics. It is based upon a knowledge of the uses and potentialities of computers. (Details of this stage appear earlier in this pamphlet.)

1.2 The second stage, Advanced Certificate for Computer Personnel (320), is intended to provide a more advanced study of computer techniques, especially programming. It is designed for students who will normally have already completed the course at Certificate level and who will be likely to have, or to be preparing for, some responsibility for data processing work.

2. Curriculum

Courses at Advanced Certificate level should include the following curriculum:
A. Computers—Theory, Practice, and Applications.
B. Logic and Numerical Mathematics for Information Processing.
C. Information Processing.
In addition, courses should wherever possible include general studies (see 12 below).

3. Course of Study

3.1 The scheme has been designed on the assumption that a minimum of 480 hours will be available for theoretical and practical work on the syllabuses. In addition, it is recommended that there should be a further allocation of time for general studies (see 12 below).

The organization of courses will vary according to the requirements of the locality and it is strongly recommended that as flexible an approach as possible should be adopted. No one particular type of course may be entirely suitable and principals will no doubt wish to consider all possibilities and combinations of part-time day, block release, and full-time courses.

For all courses it is essential that there are adequate arrangements for both theoretical and practical course work. For part-time day release courses, the minimum of 480 hours should be available. For block release and full-time courses, it will be necessary to ensure that students gain the necessary practical experience in addition to their course work and a minimum of 720 hours is recommended for the course.

3.2 The selection of students for courses is entirely at the discretion of the college authorities. It is, however, suggested that younger students should have previously completed the course at Certificate level, or have some other suitable qualification and computer experience. Older students may well be allowed to enter directly the course at Advanced Certificate level provided that they have the necessary ability and computer experience.

4. Approval of Courses

4.1 Courses under this scheme require approval by the Institute. Principals of colleges should apply to the Institute for approval of a course not less than 6 months before it is due to start.

Courses will not be approved unless there are adequate facilities for the theoretical and practical work and there are satisfactory arrangements for the proper maintenance of the relevant higher level programming languages (see 6.3 below). Details of the minimum equipment required may be obtained from the Institute (see 10 below).

Where courses are offered outside the British Isles, they must be conducted at a technical college or similar establishment provided by a Government Education Department, or by some other organization which agrees to open the college to inspection by, or on behalf of, the Institute and by the relevant Government Education Department.

4.2 In the case of courses in the British Isles, applications should be made on Form APP, and in the case of courses outside the British Isles, on Form F.2045. Copies of these forms may be obtained from the City and Guilds of London Institute, 76 Portland Place, London, W.1.

5. Notification of Courses

Centres proposing to submit entries for the examination should notify the Institute of their courses of study annually on Form 12.

6. Examination

6.1 The examination for the Advanced Certificate for Computer Personnel offered annually by the Institute will comprise:

320/1/01, 320/1/02 Written papers (3 hours each) on all sections of the syllabus.
320/1/03 Written paper (3 hours) on problem analysis and methods of solution.
320/1/04 Project type problem (about 20 hours)—see 6.2 below.
320/1/05 Oral examination.

6.2 Project type problems should be suitable for students to work on in groups of three or four. They should be designed to extend over a period of about 20 hours and to include operations selected from those of problem specification to implementation and documentation, for example:

(*a*) problem specification and analysis;
(*b*) data capture and handling;
(*c*) systems design;
(*d*) construction of flowcharts;
(*e*) coding;
(*f*) program efficiency;
(*g*) program and data preparation and verification;
(*h*) storage allocation;
(*i*) input and output routines;
(*j*) program development testing and checking;
(*k*) overall documentation.

Colleges will be responsible for setting and marking the project type problems. The problems are to be submitted to the Institute for moderating before any work on them has started; submission should be at the latest by 1st November in the year prior to the examination. The candidates' work on the problem must be marked by the college and the marked work must be submitted to the Institute at the latest by 1st June in the year of the examination.
Arrangements will be made for the oral examination of candidates on their work by local examiners appointed by the Institute.

6.3 In the examination, candidates will be required to comprehend questions written in ALGOL 60, but in answering such questions and in any applications programming they may use any higher level programming language for which arrangements satisfactory to the Institute are in existence for the proper maintenance of the language. Candidates must clearly state the language used (e.g. ALGOL, CLEO, COBOL, FORTRAN, NEBULA, PL1) and the form of the language.

6.4 The general regulations applicable to the conduct of these examinations are given in the Institute's Form 1—General Regulations and Calendar.

7. Entry to Examination

7.1 **Internal Candidates**

Candidates who will have satisfactorily completed an approved course of study must make their entries through the college authorities by the prescribed date (see Tables A and B in the Institute's General Regulations and Calendar—Form 1).

7.2 **External Candidates**

Candidates who have valid reasons for not attending an approved course of study may apply to the Institute for permission to take this examination. Applications must be made by 1st November in the year prior to examination and forms (Form CP/XA) for this purpose may be obtained from the Institute.
Permission will be granted only in exceptional cases where there are valid reasons for not having attended an approved course, and where the Institute is satisfied as to the candidate's experience and preparation for the examination. Candidates to whom it has been granted must make arrangements with the local secretary at their nearest examination centre for the necessary accommodation, including accommodation for the project type problem, and for their entries to be sent to the Institute by the prescribed date (see Tables A and B in the Institute's General Regulations and Calendar—Form 1).

7.3 Local Secretaries will be required on Form CS (i) to certify that all internal candidates entered will have completed the college course, including the necessary practical work, and (ii) to give a list of all external candidates entered.

8. Candidates Overseas

8.1 **Internal Candidates**

Candidates who will have satisfactorily completed an approved course of study (see 4 above) will be accepted for examination at centres overseas under the same conditions as in 7 above.

8.2 **External Candidates**

Candidates who have not attended an approved course of study will not be accepted for this examination at centres overseas.

9. Award of Certificates

Results in the examination as a whole will be issued in four classes, and for the individual parts of the examination in eight grades. The relationship between grades and classes is:

Pass with Distinction	— Grades 1 and 2
Pass with Credit	— Grades 3 and 4
Pass	— Grades 5 and 6
Fail	— Grades 7 and 8.

Each candidate will receive a record of performance giving his result in terms of class and grades. Successful candidates will receive the Advanced Certificate for Computer Personnel showing the class of their result in the examination as a whole.

10. List of Equipment

A list of equipment indicating the minimum requirements for courses under this scheme at Advanced Certificate level has been prepared by the Institute. The list may be obtained on application to the City and Guilds of London Institute, 76 Portland Place, London, W.1. Applications should state the subject (320).

11. List of Textbooks and Works of Reference

A list of textbooks and works of reference has been prepared by the Institute for the information of those interested in the scheme at Advanced Certificate level. The list is not exhaustive and it is emphasized that the Institute's examinations are not set on any specified books. The list may be obtained on application to the City and Guilds of London Institute, 76 Portland Place, London, W.1. Applications should state the subject (320) and be accompanied by the appropriate postage.

12. General Studies

12.1 Courses at Advanced Certificate level under this scheme should, wherever possible, include general studies. These are particularly important to computer personnel, who must be able to express themselves clearly and logically. In addition, for those whose work may at some time involve responsibility for the work of others, the development of broad interests and sympathies is important. The allocation of time for the teaching of general studies should be in addition to that for work on the technical and related studies (see 3 above).
It is suggested that the work might include oral, visual and written communication (including the use of the English language). Also, in view of the wide and increasing applications of the computer, the social impact of computers might be included, together with the work on topics such as those covered in the Certificate level syllabus together with work on topics such as those covered in the Certificate level syllabus in Related Studies.

12.2 The Institute will, however, not examine these subjects or require completion of a course in them as a condition of eligibility for the examinations for the Advanced Certificate for Computer Personnel.

ADVANCED CERTIFICATE FOR COMPUTER PERSONNEL

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Syllabuses

Notes:

(*a*) Students will be expected to have a knowledge of the syllabuses at Certificate level (319).

(*b*) Students will be expected to have practical programming experience and to develop and test programs on a computer available to the college. In the examination, they will be required to comprehend questions written in ALGOL 60, but in answering such questions and in any applications programming, they may use any higher level programming language for which arrangements satisfactory to the Institute are in existence for the proper maintenance of the language. Candidates must state clearly the language used (e.g. ALGOL, CLEO, COBOL, FORTRAN, NEBULA, PL1) and the form of the language.

(*c*) Practical work must include practice in all items under Sections A.2 to A.5 inclusive, as well as in applications arising from Sections B.1 to B.3, and C.1 to C.3 inclusive. Attention should be given to:

(i) documentation, including the preparation of overall and detailed flowcharts;

(ii) the preparation of test cases by program and of auxiliary programs to test main program;

(iii) planning programs in block structure to facilitate testing;

(iv) the use of tracing, monitoring and similar techniques in program development.

(*d*) (i) Use of terms should be in accordance with B.S. 3527;

(ii) use of flowchart symbols should be in accordance with B.S. (shortly to be published).

(*e*) Explanatory notes on the syllabuses appear later in the pamphlet.

A. Computers—Theory, Practice and Applications

A.1 Introduction

(*a*) Background to the development of computers.

(*b*) Present conceptions of a computer.

(*c*) Present and possible future applications of a computer.

A.2 Fundamentals of Computer Hardware

A.2.1 The Computer System

Revision of Section B.1 of syllabus at Certificate level, with further consideration of the central processor and control units, all types of storage device, peripheral equipment (on-line and off-line), and with extensions to cover the following:
Data retrieval and random access devices; data collection and transmission, and real-time facilities; optical, magnetic and other techniques of character recognition; graphical displays; advantages and disadvantages of standard interfaces.

A.2.2 Input and Output Media

Revision of Section B.2 of syllabus at Certificate level, with special reference to the physical characteristics of punched cards, paper tape and magnetic tape; character representation on these media and a survey of codes in common use; printed output—a survey of printing techniques, types of stationery, principles of form design

(with particular reference to pre-printed stationery); paper throw control, quality and style of print requirements; other media—magnetic cards, magnetic cartridges, photographic techniques.

A.2.3 Introduction to Logic and Internal Operation of a Computer System

Logic of computer design; symbolic representation of logic circuitry; character representation within the machine; character sets and their relevance; serial and parallel operation modes; time-sharing; queueing, simultaneous mode operations; storage configurations.

A.3 Elements of Systems Analysis

(*a*) Formulation and study of problem.
(*b*) Clear statement of possible solutions and their implications.
(*c*) Feasibility, technical and financial.
(*d*) Problem specification; overall flow-charting.
(*e*) Breakdown to detailed flow-charting.
(*f*) Further detailed flow-charting for direct computer application.
(*g*) Systems proving.
(*h*) Checking procedures and diagnostic aids.
(*i*) Construction of model system.
(*j*) Systems documentation.

A.4 Programming

A.4.1 Theoretical

Revision of Section A.4 of the syllabus at Certificate level with further reference to the development of software, and with extensions as follows:
(*a*) Familiarity with ways in which the operating system or executive system can assist with complicated organizational problems such as may arise in A.4.2(*b*) and (*c*) below, and with the requirements and design of such systems.
(*b*) Study of programming systems including single- and multi-address machine codes; relative, symbolic and indirect addressing schemes; assembly languages, functions of assemblers and macros; translators, interpreters and compilers; the structure of, and techniques used by, compilers, the use of specially generated sub-sets for particular programs; the characteristics of multi-machine programming languages.
(*c*) Familiarity with several different methods of internal file sorting and with the techniques used for both three and four tape sorts; multi-reel sorting.

A.4.2 Practical and Applications

Revision of Sections A.2 and A.3 of the syllabus at Certificate level with further reference to problem specification and analysis and to applications programming, with an extension of detailed programming to include the logical operations, shifting, double-length working and indirect addressing.
The emphasis will be on practical program writing and documentation, and considerable attention will be paid to the segmentation of programs and the importance and effects of conventions, program proving and efficiency. Students will be expected to work in teams for this purpose.
(*a*) Study of, and practice in, the use of operating systems for both production and monitor runs; investigation of the facilities of executive or supervisory systems.
(*b*) Detailed study of the following:
(i) data structures, such as one and two dimensional arrays, files, fixed and variable length records and fields, lists and list structures;
(ii) peripheral control programs for magnetic backing storage input and output, punched cards and printers;

(iii) conversions at the input and output stages with particular reference to both the peripheral and internal computer codes and representations.
(*c*) Detailed studies of the organization of multi-level storage, the allocation and transfers of program and data within the storage media.
(*d*) Further detailed flow-charting study of both a suitable low-level and a high-level code for practical applications.
(*e*) Program proving techniques involving off-line testing, the use of the computer in the development of programs and the design of test data; study of the diagnostic facilities provided by the operating system and the appropriate software schemes.
(*f*) Further documentation, including the importance and effects of maintenance and development of programs and the classified library.
(*g*) Study of, and practice in the use of, searching and sorting methods including at least one for internal file sorting and one for magnetic backing store devices; the use of sort generators.

A.5 Operations

(*a*) Appreciation of the need for computer room organization, and the operations involved in relation to: environmental control; provision of paper tape, punched card, magnetic tape; hardware components; liaison with the maintenance team.
(*b*) Hardware factors; input speeds; input layout; number of devices; number of channels; checking requirements and efficiency; re-input systems.
(*c*) Data preparation; punched cards, paper tape, mark sensing by-products systems, dual purpose cards, character recognition.
(*d*) Data transmission; line facilities and equipment required; techniques for on-line and off-line systems; error detection and correction; general examples of use of data transmission; factors in the choice of data transmission; future developments.
(*e*) Data verification; checking; minimum checking requirements; control procedures; scrutiny; code numbering of records; self-checking systems
(*f*) Marshalling of input and output; control; form numbering; form cutting and bursting.
(*g*) Job scheduling by sequential and time-sharing techniques.
(*h*) Console operating; considerations on sequential processing machines and on time-sharing machines.
(*i*) Operating manuals.
(*j*) Magnetic tape library: control and discipline.
(*k*) Punched cards, paper tapes, and other media: storage, handling and control.
(*l*) Records: computer room logs; performance statistics; machine usage statistics.

B. Logic and Numerical Mathematics for Information Processing

Note: In the examination, ability to prove the mathematical theorems implied in the syllabus will *not* be required. The aim of the syllabus is to provide a general knowledge of the concepts which students may meet in their work, and relevant questions in the examination will reflect this approach.

B.1 Symbolic Logic

(*a*) Revision of Section D.1 of Certificate level syllabus.
(*b*) Connectives and compound statements. Truth tables. Logical possibilities. Tree diagrams, with applications to lists. Decision trees. Introduction to Boolean algebra. Logical relations.
(*c*) Parenthesis—free notations, e.g. Polish, reverse Polish. Syntactic definitions.

B.2 Mathematics

(*a*) Revision of relevant parts of Sections C and D.2, 3, 4, 5, and 8 of syllabus at Certificate level, with further emphasis on growth and propagation of errors in numerical processes, leading to need for multilength arithmetic; algebraic solution of

linear programming problems; use of calculus to estimate areas and volumes; smoothing techniques for checking validity of data and forecasting trends.
(*b*) Finite mathematics, including elementary permutations and combinations; manipulation of data structures of various types; use of simple difference equations.

B.3 **Statistics**

Revision of Section D.6 of Certificate level syllabus, including the addition and multiplication theorems for probability; calculation of mathematical expectation; theory of generation of normal and rectangular distributions, methods of generating pseudorandom numbers; use of standard statistical tables.

C. Information Processing

Note: In this syllabus the term "management" is used to cover those activities which are concerned with the directing of men, materials, machines and money, singly or in combination, towards an identifiable objective.

C.1 **Process of Management**

(*a*) Forecasting, planning and co-ordination and control of group activities; leadership, supervision, span of control; delegation of responsibility and authority; administrative and executive management.
(*b*) Executive Management: determination of management objectives; primary and subsidiary objectives; decision as the choice between alternative courses of action; decision-making as the distinctive function of executive management.
(*c*) Administrative Management: determination of the information needs of management operations; organization structure; communication and information flow; levels of decision; the central role of information in the decision-making process; collection, classification and coding, analysis, selection and presentation of information for management decisions and operations; routine and non-routine decisions; evaluation of the consequences of management decision; simulation.

C.2 **Measurement and Control of Management Operations**

The monetary unit as a measure of management operations; the nature and financial recording of transactions; compilation of an account by the sorting and collating of first records; function of and relationship between various accounts; control of accounts by double entry; idea of cost in financial measurement; elements of cost and the compilation of cost accounts.
Financial recording as a means of forecasting and control; information as a means of measurement and control; time scheduling as a means of measurement and control; central role of time and information networks; measurement and control of machine and physical operations (e.g. machine tool control, production control, process control); measurement and control of human operations; control by exception, feed-back and self-regulation; control of information flow; networks and operational planning.

C.3 **Computer and Administrative Management**

The processing of information—preparation, transmission, recording, analysis, selection, presentation; information flow and the integration of management operations; the computer as a means of information processing and simulation.

EXPLANATORY NOTES

1. It is expected that students attending courses at Advanced Certificate level will be actively associated with the day to day work of a computer installation. The Certificate level was intended primarily for "junior" computer personnel and it is suggested that the Advanced Certificate may be appropriate for those having or likely to have some measure of responsibility in particular installations. Although the scheme for the Advanced Certificate is therefore intended to follow that for the Certificate, it is possible that a number of students may directly enter the Advanced Certificate course. These students may be drawn from a wide range of interests and may be specialists who, having completed their training in, for example, science, accountancy, economics, engineering, are engaged in the field of data processing.
2. The scheme offers no specialist options, although it is recognized that students will be working with a large variety of different applications. The view taken in designing the syllabuses has been that the specialist knowledge required to initiate applications in, for example, scientific, commercial or process control fields, would be acquired in other courses, already provided.
3. The scheme has as its core the syllabus "Computers—Theory, Practice and Applications". It is recommended that rather more than half the teaching time (excluding any allocation for general studies) should be devoted to theoretical and extensive practical work on this syllabus. The other syllabuses are "Logic and Numerical Mathematics for Information Processing" and "Information Processing". In the first of these, the basic computer mathematics is extended beyond Certificate level, and the second provides a detailed introductory treatment of the provision of quantitative information to management at various levels and is important for all whose work will in some way be concerned with this aspect of computer work.
4. A knowledge of the syllabuses at Certificate level is assumed throughout.
5. On two-year courses with a minimum of 240 hours' teaching time in each year, it is suggested that, for students with appropriate qualifications on entry to the course, the teaching time over the two years might suitably be allocated in the ratio 3:1:1 to "Computers—Theory, Practice and Applications", "Logic and Numerical Mathematics for Information Processing", and "Information Processing" respectively. Where English and general studies are included in courses, the allocation of teaching time to these subjects should be in addition to that for these technical and related subjects.
6. The scheme is adaptable to the various types of part-time course, e.g. day release or block release, supplemented as necessary by evening study. The precise organization will naturally vary according to the requirements of the locality and it is strongly recommended that as flexible an approach as possible should be adopted in the organization of courses.
7. In planning the scheme, concurrent development of all subjects over the course as a whole has been assumed. Practical work, as indicated in the syllabus, is of vital importance and at all times students should be taught the best principles of computer room discipline in both the handling and the treatment of equipment and stationery. To assist students in this practical work, there must be available an adequate supply of the relevant programming and operating manuals.
8. Good communications, both oral and written, are essential in computer work and extensive practice in communication, including presentation of information and report writing, must be given throughout the course. Students must learn to document and file their work so that it is readily accessible.
9. More detailed notes on the individual syllabuses are given below. It is suggested that colleges running courses might seek assistance on a regional basis from specialist organizations, on specific aspects of the syllabuses. The desirability of the complete co-ordination of the course as a whole is clearly evident and cannot be over-emphasized.

Computers—Theory, Practice and Applications

10. The first requirement is that students should have a thorough knowledge of the subject matter required for the Certificate level and references are made to the Explanatory Notes for this level as appropriate.
11. Students should be able to formulate and program problems on their own (see note 7—Certificate level, and also note 23 below), but further detailed guidance and practice should be given. It is recommended that students concentrate on proficiency in one higher level programming language (see note 12 below), to a level such that problems can be tackled easily; other languages can be studied as appropriate (see note 13 below). It is envisaged that the normal two-year, part-time course might involve the preparation of some thirty short programs, and that in the implementation of each program, students will require three periods of access to the computer. This programming work would not, it is expected, be in connection with the project-type problem (see regulation 6.2).
12. In the examination, candidates will be required to comprehend questions written in ALGOL 60, but in answering such questions and in any applications programming, they may use any higher level programming language for which arrangements satisfactory to the Institute are in existence for the proper maintenance of the language. Candidates must clearly state the language used (e.g. ALGOL, CLEO, COBOL, FORTRAN, NEBULA, PL1) and the form of language.
13. Students should acquire a detailed understanding of the construction of programs and their place in the hierarchy of a computer system. This will lead to the properties of assemblers and compilers, and executive and control routines. Compiler construction based, for example, on the rules of syntax or on the methods of precedence should be discussed. It should be shown, for example, how simple arithmetic expressions can be translated.
14. It is anticipated that by the end of the course teams of three or four students will have developed to production stage an object program similar in size and complexity to the maintenance of a standing file. Within this program they should include the application of a variety of input, output, and bulk storage devices, magnetic tape files. or some equivalent of these. An important aim is to bring students to the point where they can discipline themselves to terminate a large-scale problem at a realistic stage in a reasonable time. This work might, if appropriate, form part of the project-type problem (see regulation 6.2).

Logic and Numerical Mathematics for Information Processing

15. The ideas and terminology of this section may be unfamiliar; however, both are essential to an appreciation of many aspects of computers and their applications. Much of the material is well covered in the book "Finite Mathematics with Business Applications" by Kemeny, Schleifer, Snell and Thompson (Prentice Hall, 1964). A simple description of Polish notation has been given in the *Computer Journal*, C. L. Hamblin, Vol. 5, page 210, and A. J. T. Colin, Vol. 6, page 67. "An Introduction to Numerical Mathematics" by E. L. Stiefel may also be found helpful. The following brief notes may help to clarify the subject matter and suggest the relevant applications.
16. In the examination, ability to prove the mathematical theorems implied in the syllabus will *not* be required. The aim of the syllabus is to provide a general knowledge of the concepts which students may meet in their work, and relevant questions in the examination will reflect this approach.
17. Symbolic Logic: The notations and operations of symbolic logic occur in two distinct contexts in computer work—(i) the organization of a problem—this is largely a logical process and such processes are well described in terms of symbolic logic, the language ALGOL introducing Boolean variables for this purpose; (ii) the logical description of a computer in terms of logic diagrams—it is very useful for a computer

user to be sufficiently familiar with such diagrams to give him common ground with computer engineers. The main purpose of studying Polish and similar notations is that they are frequently used in special programming associated with compiler writing. A study of syntactic definitions should enable students to understand the syntactical description of a programming language such as ALGOL. The latter describes syntax in a notation known as Backus Normal Form.

18. Mathematics: Revision and topics requiring further description are suggested. It is particularly important that an appreciation of errors in numerical processes is maintained and extended in the advanced syllabus. The various effects of noise in data, errors arising from floating point numbers and round off and errors inherent in a particular process should be studied. The student should be aware of the dangers of error growth and this could be demonstrated suitably by desk machine work. The need for using multi-length arithmetic should be understood and as illustrations of this need, examples may be taken from linear programming and solution of ill-conditioned simultaneous equations. Simple differences, in the form of integers, can be used in many applications from finance to smoothing and interpolation in numerical analysis.

19. Statistics: Pseudorandom number generation and rectangularly distributed data are included in this syllabus, since so many modern computer methods make use of them. Simulation of physical systems in a computer often demands the simulation of random patterns to represent a physical environment. The so-called Monte Carlo methods of numerical analysis are of increasing importance and make use of pseudorandom numbers.

Information Processing

20. Information processing has until recently depended on the use of a team of people to carry out the basic clerical operations of reading, writing, communicating, copying, sorting, comparing, filing and calculating. Economic and technological progress has brought with it an ever increasing volume of information on which these operations have to be carried out. Indeed, the rate of such progress has been determined to a great extent by the ability of the administrative system to handle this work of information processing.

21. Since the turn of the century, and even earlier, machines have been designed to help people to process this growing volume of data, and to free them for more specifically human tasks by carrying out almost automatically some of the simple repetitive clerical operations. The electronic digital computer, operating under the control of man-made instructions stored within itself, and itself controlling the operations of other items of equipment, each capable of performing at least one of the basic clerical operations, has now made it possible for many of the successive stages of an administrative system to be carried out as a single integrated process, at a speed and with an accuracy far beyond that possible by unaided human effort.

22. In order that students may become capable of exploiting to the full the capabilities of this complex tool, they must learn not only the construction of the machine itself and the numerical and logical ideas which provide the foundation for its design and for the construction of the programs which enable it to operate, but also the general structure of the processes which it has been designed to serve.

23. The background of "Related Studies" at Certificate level will have introduced candidates to the general ideas of information and the ways in which it is used. They must now be led to a more detailed analysis and understanding of the administrative system and the part played in it by the techniques of financial and cost accountancy. This syllabus is not intended to provide education and training in these techniques themselves, but only an understanding of them sufficient to enable candidates to appreciate how the computer is used to perform them as part of its wider function as an information machine. This syllabus is concerned above all with the basic requirements of an administrative system which is capable of being served to advan-

tage by a computer. Any common scientific, industrial or commercial background shared by a particular group of students could be used to provide concrete illustrations of the validity of these fundamental ideas and an excellent framework for the project requirements of the course (see note 11 above).

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Professional, Scientific and Miscellaneous
319. Certificate for Computer Personnel
320. Advanced Certificate for Computer Personnel

Printed litho in England by
Coes the Printers Limited Rustington Sussex
Published by the City and Guilds of London Institute
76 *Portland Place, London, W.*1.