CITY AND GUILDS OF LONDON INSTITUTE
76 Portland Place, London W1N 4AA

236 Electrical Installation Work

		For examinations in
236-1	Part I Certificate	1983–1985
236-2	Part II Certificate	1983–1985
236-3	Course C Certificate	1983–1985

Special Note

EXAMINATIONS OF REGIONAL EXAMINING BODIES IN ENGLAND AND WALES

Where examinations in Electrical Installation Work corresponding to the Institute's Part I examination are held by a Regional Examining Body, a local education authority in membership with the Regional Examining Body will normally arrange that its students will take the examination of the Regional Body. The City and Guilds of London Institute will accept from such a local education authority entries for the Part I examination only upon the specific request of the Chief Education Officer concerned confirming that the authority, having considered the matter, desire the candidates in question to take the examination of the City and Guilds of London Institute.

The Institute will recognize success in the examination of the Regional Examining Body as corresponding to success in the Institute's examination.

The Regional Examining Bodies to which this note applies are:

East Midland Further Education Council

Northern Council for Further Education

North Western Regional Advisory Council for Further Education incorporating the Union of Lancashire and Cheshire Institutes

Welsh Joint Education Committee

West Midlands Advisory Council for Further Education incorporating the Union of Educational Institutions

Yorkshire and Humberside Association for Further and Higher Education

NOTE ON SCHEME REVISION

In this edition, which replaces the previous edition dated 1979-1981, the scheme for Electrical Installation Work Course C has been revised. The following are the arrangements for phasing in and out the new and old examinations:

		First examination
236-3	Electrical Installation Work Course C	May/June 1983
		Last examination
235-3	Electrical Installation Work Course C	May/June 1983 (resits December 1983)

The syllabuses for 236 Electrical Installation Work Part I and Part II remain the same as in the previous edition subject to the inclusion of the amendments published August 1981 incorporating the 15th Edition of the IEE Regulations.

CITY AND GUILDS SCHEMES FOR THE ELECTRICAL AND ELECTRONICS INDUSTRY

General Vocational Preparation

Foundation Course in Engineering (686)
Numeracy (364)
General Employment Award
Communication in Technical English (847)
Communication Skills (772)

Specific Vocational Preparation

Electronics Servicing (224)
Electrical and Electronic Craft Studies (232)
Electrical Engineering Technicians (803)
Electrical Installation Practice (823)

Post-Experience and Careers Extension

Further Education Teachers (730)
In-service Courses for Teachers (731)
Achievement Testing (732)
Work Study (742)
Quality Control (743)
Organizational Studies (771)

The 800 series examinations are normally available only at overseas centres.

A catalogue of syllabus pamphlets, sets of past question papers and other Institute publications is available with order forms from the Sales Section, City and Guilds of London Institute, 76 Portland Place, London W1N 4AA.

PREFACE TO THE SCHEME FOR 236 ELECTRICAL INSTALLATION WORK

1 General Introduction

The scheme for Electrical Installation Work is one of technical education designed for craft students – whether apprentice, trainee or adult trainee.

Important considerations in the provision of an education scheme are

(a) rapid changes in technology: it has become increasingly important that craft students should be educated in the scientific and technological principles employed in industry if they are to be able to understand, appreciate and apply new techniques as they are introduced;

(b) the importance of understanding the industrial environment
   (i) changing technology may increase the overlap between craft activities without necessarily removing the need for specialist and traditional craft skills and knowledge. Individuals need more than ever to study their own craft not only to understand their own function but also to be able to cooperate with others whose craft activities affect their own,
   (ii) understanding the job makes job satisfaction more probable,
   (iii) the attainment of an industrially-recognized standard of education increases the confidence both of the individuals and of their industries' customers,
   (iv) the ability to communicate enables those engaged in craft activity to do their job, to talk about their job, to explain their ambitions and be satisfied that they have been understood;

(c) the rapid change in the pattern of social life: the attainment of a satisfactory personal status within the community, a satisfaction in personal life and an opportunity to engage in worthwhile leisure pursuits are as important to job performance as they are to self-respect.

2 Aims

The aims of further education given in the various levels of this scheme are to

(a) provide the knowledge and appreciation of techniques and materials which will be needed to do a job with efficiency and understanding;

(b) provide a broad understanding of relevant science and technology with background studies of industry, so that the students
   (i) acquire an understanding of the principles of the individual craft,
   (ii) appreciate the work and problems of those engaged in associated occupations and the relationship between their activities,
   (iii) are better equipped to adjust to changes in the nature of their work caused by technological development, changes in industrial conditions or changes in the pattern of employment;

(c) provide for continued study in preparation for advancement in industry;

(d) widen the students' understanding of the industry in which they work and of the society in which they live;

(e) develop the students as persons so as to encourage the growth of
  (i) mature attitudes in industry and society in general,
  (ii) powers of thought, reasoning and communication, and
  (iii) an appreciation of the value of learning.

3 The Students

The scheme has been designed for craft students who are attending technical colleges for courses of further education, and who are employed and gaining practical experience in industry. Some may be undergoing more formal training on or off the job, the nature and quality of which will vary considerably. The majority will be craft apprentices in the electrical contracting and supply industries, but the scheme is also intended for those whose work involves electrical installation, or the maintenance, repair or modification of existing installations. Some will be adult trainees under a formal training service agreement and they too will find the courses generally suitable.

4 Structure of the Scheme

The scheme provides for certification at three levels – Part I, Part II and Course C.

Part I will normally be taken after about 600 hours of study by those capable of achieving Part II in the stated time. Nevertheless there may be a number of candidates who need up to 900 hours of study to achieve the Part I level, including perhaps a period of introductory study to make good any deficiencies in their level of earlier educational achievement. Part II following on from Part I represents the minimum normal achievement goal within the equivalent of three years of day release. It provides for the further educational requirements of the Joint Industry Board-approved electrician and, together with a satisfactory industrial achievement, will form the basis of his right to apply for grading. For those who pass Part I and Part II and provide satisfactory evidence of industrial skill and achievement the Institute offers the Electrician's Certificate.

Course C requires 480 hours of technical studies and provides the requisite technical knowledge for a technician electrician as defined by the Joint Industry Board for the Electrical Contracting Industry. Previous success in installation work courses in 236 Parts I and II Certificates or 235 Course B or a 232 Electrical and Electronic Craft Studies Certificate is required. The title 'Course C', originally used in the old scheme, has been retained in view of the longer duration and integrated nature of courses compared with Part III level studies in other subjects.

5 Content of the Scheme

Scheme content in Parts I and II is described in terms of craft theory, associated subjects and practical activities arranged in a number of 'areas of activity'. The scheme also includes Study of the Electrical Industries (both Supply and Contracting) and General Studies.

Each syllabus contains a statement of course objectives. They state in general terms what the student should know, understand, or be able to do at the end of each part of the scheme. They form the basis of the examination pattern and are examined within the limits of the stated syllabus content. Read in conjunction with the stated syllabus content, the objectives are intended also to provide the college with guidelines within which to develop an appropriate course of study and a pattern of specific learning objectives, appropriate to the progress and potential of its own students.

The Course C syllabuses also contain a statement of objectives which indicate the abilities the student should be able to demonstrate subject to the limits of the syllabus content together with the practical activities set out in the laboratory/workshop activities.

6 Course Organization

The scheme has been designed to suit the variety of ways in which further education courses can be provided. Day release courses over three years (or the block release equivalent to the 900 hours provided by day release) provide sufficient time for the further education aims of Part I and Part II to be achieved by the majority of those for whom the scheme has been designed, or of Part I alone for those who need the extra time. Course C requires a minimum of 480 hours of technical studies plus the additional hours required to carry out the project under supervision in the college. Day release courses over two years (or the block release equivalent) provide sufficient time for the further education aims of Course C. It is hoped that all concerned will give close consideration to the advantages of block release courses. In block and day release courses there will be a strong element of practical activity consistent with the aims of technical education. It is highly desirable that there should be full discussion and close liasion between the college and employers to ensure that the students obtain maximum benefit from coordinated programmes of industrial experience and further education.

An arrangement particularly suited to the needs of young people engaged in craft activities in industry is one where the further education is provided in close conjunction with off-the-job industrial training. Skill, knowledge and understanding can then grow naturally in proper proportion and the relationship between further education and training aims can be clearly demonstrated. Initial training can also be provided in a more suitable environment than is normally available at work. The planning of such courses must be carefully and deliberately done in order to avoid duplication and to ensure that the result is one coherent course.

236 – ELECTRICAL INSTALLATION WORK

Introduction

1 This scheme for further education courses of part-time study and related examinations is designed for apprentices and trainees engaged in electrical installation crafts and has been designed to be complementary to the training and experience students will obtain in their employment. Its purpose is to provide a sound understanding of craft processes and appreciation of related science and technology and to introduce a study of the electrical industries (both Supply and Contracting). The Part I course concentrates on installation processes and practices together with a study of electricity sufficient to promote a knowledgeable and safe approach to installation work. In addition to the technical subjects, General Studies are included in order to develop the students' ability to absorb, interpret and transmit information in spoken or written form and to contribute to their general education and personal development. The Part II course seeks to deepen the understanding of craft processes, technology and related science, to introduce a study of special installation conditions, to promote a knowledge and understanding of the regulations and conditions under which the industry operates and to introduce a study of job organization. The Parts I and II courses aim to develop further abilities in communication and responsible attitudes to work production and costs. Course C in addition aims to provide the further requisite technical knowledge for a technician electrician who will be required to plan and supervise general types of electrical installation work.

Course of Study

2 Courses based on these syllabuses may be arranged as block release or day release courses or as part of combined courses of further education and industrial training. The arrangement preferred is one of block release courses, which may be extended to include time specifically for industrial training. The time required for the courses will vary according to the abilities and opportunities of students, but the schemes have been drawn up on the assumption that the majority will complete Parts I and II in approximately 900 hours (with Part I taken after approximately 600 hours). It is recognized that some will require preliminary studies and therefore need 900 hours to complete Part I. Those who progress to Course C after success at Part I and II levels will need at least 480 hours to complete the technical studies and additional time to complete the project.

3 The subjects of the courses are shown below.

PART I
Part I Technical Studies (comprising Craft Theory, Associated Subjects and Practical Activities)
Study of the Electrical Industries (both Supply and Contracting)
General Studies

PART II
Technical Studies (comprising Craft Theory, Associated Subjects and Practical Activities)
Study of the Electrical Industries

COURSE C
Installation Work and Regulations
Electrical Science
Project Work and Laboratory/Workshop Exercises.

4 Where time and student ability permit, the syllabuses of this scheme and syllabuses from Electrical and Electronic Craft Studies may be studied simultaneously (see Appendix – Explanatory Notes).

5 It is the intention that in Part I courses, Study of the Industries should be incorporated partly into technical studies and partly into General Studies in order to provide a link between them.

In Part II courses, Study of the Industries can provide opportunity for combined projects in job planning, safe working practice, job organization and work programming.

6 General Studies are regarded as an integral part of Part I courses (see para 1) and the aim should be to allocate up to 20% of the course time to them. The Institute will not examine in General Studies and colleges are free to devise their own syllabuses and approach. Institute schemes and examinations in Communication Skills (772) and Numeracy (364) are available for incorporation into General Studies provision where this is considered appropriate. A pamphlet in which an approach to General Studies is suggested is available from the Institute also.

Entry to the Courses

7 The selection of students for the Part I course is within the discretion of colleges, in consultation with industry. Candidates who have successfully completed an appropriate Foundation Course may undertake an accelerated course. Candidates who have successfully completed an appropriate Basic Engineering Craft Studies Course, should be able to complete Part I of this scheme in a further 300 hours.
For direct entry to Part II courses a minimum education qualification of the Part I Certificate in Electrical Installation Work is required. (Possession of the Course A Certificate would satisfy this requirement.) Entrants to Course C should hold the 236 Parts I and II Certificates, or the Certificate in 235 Electrical Installation Work – Course B, or a 232 Part II Certificate in Electrical and Electronic Craft Studies (see Explanatory Notes, para 4b).

Overseas Countries

8 The Institute has introduced a series of engineering schemes to assist in the establishment of courses of study and training for trades students in technical colleges and similar institutions in overseas countries. An introduction to electrical, mechanical and automotive engineering is provided for in the Certificate in Basic Engineering Trade Subjects (subject 820). Successful students are expected to proceed subsequently to the specialized trade practice course: 823 Electrical Installation Practice.

9 Part II of the 236 scheme is also available outside the United Kingdom, to follow course 823 at those colleges which have received the Institute's approval. Course C is also available at those colleges which have received the Institute's approval. Application for approval of a course should be made on Form 2045 which can be obtained from the Overseas Department of the Institute.

Examination Regulations – General

10 The Institute's examinations are conducted in accordance with its General Regulations and Examinations Timetable (Form 1). Candidates must submit their entries through an examination centre by the date specified in the Timetable.

11 If, during the currency of the scheme, the Institute deems it appropriate to modify the pattern of the examination and awards, the necessary changes to the regulations will be notified to colleges in advance of their being applied, as well as in Form 1.

Eligibility for Entry to Examinations.

12 Candidates for the Institute's Part I examination must be internal, but for the Part II examination, candidates may also apply for approval to enter externally. Part II external candidates will be required to attend by prior arrangement with a college or other approved establishment to obtain an assessment in practical activities. Colleges should therefore accept entries from such candidates only where suitable arrangements have been made.
Both internal and external candidates for Course C must hold certificates in 236 Parts I and II or an equivalent certificate approved by the Institute. External candidates for Course C must complete the 40 hour project and will need to obtain a copy of the project from their examination centre at least six months before the examination.

(a) INTERNAL CANDIDATES
Internal candidates are those who, at the time of entry to an examination are undertaking (or have already completed), the relevant course at a college of further education or other approved establishment.

(b) EXTERNAL CANDIDATES
Candidates who have valid reasons for not having attended a course of study may, exceptionally, be given permission to enter the Part II or Course C examinations as external candidates, provided that the can satisfy the Institute as to their preparation for the examination. Applications must be made on Form 236X which must be received at the Institute not less than eight months before the date of examination.

Examinations

13 The components for the examinations in Electrical Installation Work are listed below. In each examination, candidates must take all components on their first entry. Candidates who have obtained a successful coursework grade in Electrical and Electronic Craft Studies Part II (component 232-2-12), may carry forward that grade in lieu of component 236-2-13 in Part II of this scheme. Candidates who are successful in one or more but not all of the components may carry forward their success(es) and need subsequently retake only the component(s) in which they were unsuccessful. In addition to the examinations listed, candidates who wish to may enter the Institute's Part I Engineering Craft Studies examination after approximately 300 hours of their course.

PART I		
236-1-01	Written paper (multiple choice)	2 hours
(236-1-02)	Assignments	
(236-1-03)	Coursework assessment	
PART II		
236-2-11	First written paper (multiple choice)	2 hours
236-2-12	Second written paper	3 hours
(236-2-13)	Coursework assessment	
COURSE C		
236-3-21	Installation Work and Regulations	3 hours
236-3-22	Electrical Science	3 hours
(236-3-23)	Project	40 hours

A booklet on the pattern of examinations, which gives details of examination specifications, guidance on coursework assessments, assignments and sample questions is available from the Institute.
For the Course C Installation Work paper (236-3-21) candidates will be required to take into the examination their copy of the current IEE Regulations (guides and commentaries are not allowed).

Coursework Assessments, Assignments and Project Work

14 Colleges are required for the coursework assessment and assignment components in Parts I and II to submit an assessment of the work of each student based on practical and experimental activities in the workshop and laboratory in terms of DISTINCTION, CREDIT, PASS or FAIL. The Institute may call for completed assignments from selected colleges to be submitted for review; the colleges concerned will be notified in advance.

15 In Course C, colleges are required to confirm on their project marking schedule that candidates have satisfactorily completed a programme of laboratory/workshop activities. The Course C project itself is designed to occupy approximately 40 hours in the later stages of the course. Details of the project will normally be available to colleges by June in the year preceding the examination. The December project will be the same as that set for the preceding May–June examination. Projects will be marked by the colleges in accordance with a marking schedule provided. The Institute may call for marked projects and schedules from selected colleges to be submitted for review; the colleges concerned will be notified in advance.

16 Local secretaries are required to submit on the appropriate marksheets supplied by the Institute, details of candidate assessments for these components. These forms should be returned to the Institute by 30 June, 31 December or 31 March according to the examination series.

Examination Results and Certificates

17 Each candidate will receive a record of performance giving the grade of performance for the components taken – there are four grades, 'DISTINCTION', 'CREDIT', 'PASS', 'FAIL'.

18 Certificates are awarded to candidates who pass all components of the examinations. The certificates indicate the level of examination, i.e. Part I, Part II or Course C as appropriate, and the grade of performance for each component.

The Electrician's Certificate

19 The Electrician's Certificate will be awarded to a candidate not less than 20 years of age, who has had at least four years' industrial experience in Electrical Installation Work and has obtained both a Part I and a Part II Certificate in Electrical Installation Work. (Candidates who have qualified under arrangements accepted before the introduction of this scheme will continue to be eligible.)

20 Applications should be made on Form EIW1, (available from the Certificate Unit) on which details of the applicant's industrial training and experience are required.

21 A candidate whose experience is in electrical installation on board ship, may qualify for a special Electrician's Certificate endorsed 'Shipwork'.

Licentiateship

22 This award is conferred by the Institute on those for whom a grade of Institute membership is an appropriate form of recognition of their achievements in education, training and employment. Recipients of the award are entitled to use the designatory letters LCG after their names. The following routes have been approved:

ELECTRICAL INSTALLATION WORK

(a) FOR LEVEL 2: Course B Certificate of the Institute or an REB
OR Part I (Institute or REB) AND Part II Certificates in 236 Electrical Installation Work

AND

(b) FOR LEVEL 3 AND CAREER EXTENSION TOGETHER: Course C Certificate

AND

(c) FOR INDUSTRIAL ACHIEVEMENT: The Electrician's Certificate, which includes registration as an Approved Electrician.

ELECTRICAL ENGINEERING

ROUTE 1

(a) FOR LEVEL 2: Part II Certificate in Electrical and Electronic Craft Studies
OR Electrical Installation Work – Course B Certificate of the Institute or an REB
OR Part I (Institute or REB) and Part II Certificates in 236 Electrical Installation Work

AND

(b) FOR LEVEL 3: Two Part III modular Certificates in Electrical and Electronic Craft Studies

AND

(c) FOR CAREER EXTENSION: One of the following qualifications
Institute Certificates for Work Study, Quality Control, Organizational Studies, Further Education Teachers, In-Service Course for Teachers, the Certificate or Diploma of the National Examinations Board for Supervisory Studies, Certificate in Management Studies of the Business Education Council, an appropriate grade of membership of a relevant professional body or Institute, providing that the membership was achieved by examination.
OR documentary evidence of satisfactory completion of an education and training programme in accordance with an ESITC Technician Engineering Training Recommendation or Industrial Staff Traineeship

AND

(d) FOR INDUSTRIAL ACHIEVEMENT: Possession of an ITB Craft Certificate
OR other proof of satisfactory completion of an ITB recognized programme of training
OR documentary evidence of satisfactory completion of a craft apprenticeship with an Electricity Board or of transfer from craft apprenticeship to an ESI Technician Engineering Training Scheme or Industrial Staff Traineeship

ROUTE 2

(a) FOR LEVEL 2: Part II Certificate in Electrical and Electronic Craft Studies
OR Electrical Installation Work – Course B Certificate of the Institute or an REB
OR Part I (Institute or REB) and Part II Certificates in 236 Electrical Installation Work

(b) FOR LEVEL 3 AND CAREER EXTENSION TOGETHER: Electrical Installation Work – Course C Certificate

AND

(c) FOR INDUSTRIAL ACHIEVEMENT: Possession of an ITB Craft Certificate or other proof of satisfactory completion of an ITB recognized programme of training OR documentary evidence of satisfactory completion of a craft apprenticeship with an Electricity Board or of transfer from craft apprenticeship to an ESI Technician Engineering Training Scheme or Industrial Staff Traineeship.

Recognition

23 The Joint Industry Boards for the Electrical Contracting Industry will accept possession of the Institute's Certificates in Electrical Installation Work as evidence of satisfactory educational achievements in support of applications for gradings. The Boards may from time to time issue details of other requirements (e.g. a specified period of industrial experience) for such grading, and candidates are advised to contact them for details. In particular, it must be noted that while a candidate may pass the examinations at an earlier stage of his career than is usual, this will not in itself qualify him for earlier grading.

General Regulations

24 In the case of any inconsistency between the subject regulations set out in this syllabus pamphlet and the General Regulations (Form 1), General Regulations shall prevail.

APPENDIX
EXPLANATORY NOTES

1 Aims of Further Education in this Scheme

The aims of further education are suggested in paragraph 2 of the preface. Teachers may find them of help both as a general statement of the philosophy behind the course they will develop, and as a starting point for discussions in class about what further education may offer to those willing to take advantage of it.

2 Syllabus Preparation

The syllabuses are presented to assist the teacher in two specific ways.

(a) The structure of the scheme.
The main craft aim will be success in the Part II Certificate, after gaining the Part I award. This is an educational level appropriate to the Approved Electrician in the Contracting Industry and recognized by the Supply Industry as corresponding to the Part II Certificates awarded to successful Craft Studies students. Many students will wish subsequently to proceed to Course C and to improve their grading.
The Institute has sought to provide for certificate opportunities at all the usually acceptable levels of achievement, and to state clearly what further achievement will be required to earn further certificates. Teachers will decide the actual pace of their courses having regard to the maturity, training, experience, motivation and previous educational attainments of their students. In this connection, the Institute offers examinations in every examination series for Parts I and II (December, Spring and May-June) and in December and May-June for Course C where the demand exists, and so provides maximum opportunity for flexibility in course organization.

(b) The Institute has tried to give as much guidance as possible without restricting the initiative and individuality of the teaching institutions. One example of this is the presentation of the Associated Subjects syllabus (which includes much of what has become known as 'Electrical Principles'). It would have been possible to present it only as a collected syllabus and thus, perhaps, have encouraged isolated treatment of the topics in both courses and examinations. Instead the topics have been allocated to the various 'areas of activity'. This has two advantages
(i) it invites the teacher to consider how the topics may be taught in connection with the craft theory and practical activities, and how the student may acquire the relevant knowledge through his own workshop, laboratory and classroom activities.
(ii) it suggests to the teacher and the examiner a practical context in which a knowledge of the Associated Subjects syllabus may be examined.

An additional aid to the provision of a suitable environment and context of study is to be found in the study of the Electrical Industries. The aim of these studies derives from the aims of further education listed in paragraph 2 of the preface and particularly from (b)(ii) and (d). The level of treatment must be appropriate to the abilities and stage of development to be expected of a craft student, and in colleges with construction courses, combined project exercises might be one method available.
The emphasis of the syllabuses as presented is on the intended achievements of the students, not on the content of the teachers' lessons.

3 Practical Activities

Those teaching craft subjects will appreciate that most of the items in these syllabuses can be taught effectively only when the students can see, use and in other ways come into contact with the materials, processes and equipment involved. It is assumed, therefore, that much of the teaching will take place in the workshop, or laboratory, or in a suitably equipped classroom, and will take the form of experimental work requiring active student participation not mere passive observation. For this reason, the practical activities – which form an essential part of any scheme of technical education – are described in the form of what students can do for themselves, and so both acquire their technical knowledge and demonstrate its acquisition in a practical and appropriate manner. It also makes it possible for the students to appreciate for themselves the relevance of their studies to their own ambitions and industrial activities. Industrial training will be concerned with the development of the practical skills themselves, and the course of technical education will not seek to duplicate that training. Nevertheless, it must be recognized that practical activity is a form of expression and communication, and that pride and pleasure in achievement is a powerful incentive to further study.

4 Preparing Candidates for Examinations in Both Electrical Installation Work and Electrical and Electronic Craft Studies

The overriding principle of the preparation of the schemes has been the need to have courses which can be presented as a unified whole, rather than as a series of disconnected subjects. The majority of students follow either an installation course or a single craft studies Special Study course; for them a single teaching scheme combining Craft Theory and Associated Subjects (or Core Studies and Special Studies) can be both the ideal and the norm.

For some students, however – particularly from the Electricity Supply Industry or those with appliance,distribution and maintenance backgrounds – combined courses leading to two sets of examinations, either simultaneously or in sequence, may be appropriate, and the following suggestions are offered.

(a) In the Craft Studies scheme, the overlap common to all the courses in the scheme has been identified in the Core Studies syllabus. There is further overlap between the various plant-based syllabuses in topics which would not be appropriate to the Electronics-based syllabus, for example. There is an overlap also between the Installation scheme and the syllabuses of the Craft Studies scheme. It will be important, therefore, to establish the degree of this before determining any extra time which will be needed for combined courses. It is not anticipated that such extra time will need to exceed 240 hours.

(b) Opportunity should be offered to Installation and Craft Studies students to progress to 232 Part III or 236 Course C, but it is recognized that college-based introductory courses may be needed depending on the relationship between the study completed at Part II level and the study contemplated at Course C or Part III level.

(c) To assist those planning combined courses for Supply Industry and Appliance Industry students, the Associated Subjects of the Installation Scheme are given in collected form at the end of the Part I and Part II syllabuses. This may provide a useful 'checklist' for comparison with the combined teaching scheme developed. In addition, the same coursework grade may be given for components 232-2-12 and 236-2-13.

(d) Candidates who sit both 232 and 236 Part II examinations in the same series should be entered for all components of the 236 Part II examination and the relevant special study of 232 Part II on separate entry forms. If they are successful in all components they will receive certificates for both 232 Part II and 236 Part II. The certificate for 232 Part II will show an exempt result for Core Studies and the common grade for coursework.

OBJECTIVES

236 – PART I CERTIFICATE IN ELECTRICAL INSTALLATION WORK

STUDY OF THE ELECTRICAL INDUSTRIES (SUPPLY AND CONTRACTING)

Note: the following objectives indicate in general terms the desirable achievement of the craft student on completion of the Part I Certificate Course.

1 Electricity, the Environment and the Community

1 State, in general outline, the environmental effects of the use of electricity in terms of
   (a) the efficient use of natural resouces, including fuels and natural forces used in power generation
   (b) the control of pollution
   (c) the disposal of power station waste products (e.g. coal and nuclear wastes).
2 State the purpose and function of the 'national grid'.
3 State the means used to carry electricity supplies from generator to consumer, the approximate voltages appropriate to each stage and the means used to maintain those voltages.
4 State the aesthetic effects of the siting of power stations and transmission lines.
5 State, in general terms, the effects of the introduction of electricity and electrically-operated devices on
   (a) comfort, safety, health, welfare and security at home and at work
   (b) the entertainment and leisure pursuits available
   (c) 'labour-saving' at home and in employment
   (d) the means of communication and data storing.

2 The Process of Installation

1 Demonstrate a knowledge of the structure of a contracting firm and of the roles and responsibilities of employers and employees.
2 Demonstrate a knowledge of the stages in designing an electrical installation from defining needs to production of working drawings.
3 State the role of each of the main members of the design and installation team (include the role of the client).
4 Indicate the main requirements for establishing and maintaining good working relationships on site, including cooperation with other trades.
5 Outline the general requirements for safety and welfare in installation work.
6 Describe the importance of correct attitudes towards the customer and the care of his property.

OBJECTIVES

236 – PART I CERTIFICATE IN ELECTRICAL INSTALLATION WORK

TECHNICAL STUDIES

The following objectives indicate in general terms the abilities which the craft student should be able to demonstrate, SUBJECT TO THE LIMITS OF THE SYLLABUS CONTENT, when presented for the Part I Certificate Examination.

1 Health and Safety

1 Recognize and indicate potential health and safety hazards in the handling and use of materials and equipment and in work situations.
2 Demonstrate knowledge of the responsibilities of employer and employee with regard to safety.
3 State in simple terms the application of relevant statutory regulations to given work situations.
4 Describe how to prepare and carry out work with due regard to safe working procedures and safety precautions.
5 Demonstrate knowledge of procedures in the event of accident or dangerous occurrence in working.
6 State the extent of general first aid to be offered in given situations.
7 Make appropriate reports.

2 Installation Circuits

1 Describe the functions of the listed components of an electrical circuit.
2 State the correct circuit connections for voltmeters, ammeters, wattmeters, kilowatt-hour meters and power factor meters.
3 Give examples of the heating, magnetic and chemical effects of an electric current.
4 State the use of common electrical units of measurement and their relationship to each other.
5 Prepare diagrams of, and explain the action of, listed circuits.
6 Describe the basic principles of operation of simple a.c. and d.c. generators.
7 Describe the principle of minimizing interruption of supply by graded protection devices.
8 State how single-phase supplies are derived from the three-phase four-wire system and why loads should be balanced.
9 Perform simple calculations related to series and parallel circuits.
10 Perform simple calculations involving energy, power, voltage and current.
11 Relate power rating and energy consumption of simple electrical appliances; perform related calculations.
12 Demonstrate knowledge of the construction and operation of tungsten and fluorescent lamps and their accessories.
13 State the effect of inductance and capacitance in a.c. circuits.
14 Describe the use of capacitors for power factor improvement.
15 Describe the principle of transformer action and the relationship between current, voltage and turns.
16 Describe simple fire, call, intruder alarm, bell and indicator systems.
17 Describe the installation and maintenance of emergency lighting systems.
18 Describe the action, installation, maintenance and charging of secondary cells.
19 Calculate voltage drop in emergency lighting circuits, including distributed loads.

20 Calculate charging and discharging currents of batteries.
21 Demonstrate knowledge of the requirements for the installation of socket outlets and appliances for cooking, water heating and space heating.
22 Describe the operation of thermostats and simmerstats.
23 State the special requirements for electrical installations in bathrooms and shower cubicles.

3 Materials Commonly Used in Electrical Installation Work

1 Recognize and name the materials of the craft.
2 Classify materials as conducting or insulating, metallic or nonmetallic, ferrous or nonferrous, thermosoftening or thermosetting.
3 Relate the main properties of materials to their uses in electrical installation work.
4 State reasons for the selection or rejection of materials for given jobs.
5 State means of protecting materials from damage in store, transit, or installation or by corrosion.
6 Determine resistance from dimensions and resistivity.
7 Solve, by proportion, simple problems involving resistance and dimensions.
8 Describe the effect of temperature on the resistance of common conducting and insulating materials.

4 Tools, Equipment and Working Processes

1 Recognize and name the tools and equipment required to undertake specified jobs.
2 Make lists of tools and equipment required for specified jobs.
3 Describe how to assemble and adjust tools and equipment and check for working order.
4 Recognize the effects of faults in tools and equipment, and describe appropriate actions to remedy the faults.
5 Demonstrate knowledge of basic working principles of tools and equipment.
6 Demonstrate maintenance and care of tools and equipment.
7 Select suitable methods of bending, cutting, connecting and joining materials.
8 Describe the preparation of surfaces for the erection of wiring systems and 'making good'.
9 Sketch simple supports and brackets.

5 Measurement and Setting Out

1 Select and use suitable measuring and setting-out equipment.
2 Take and record dimensions from installation situations and scale drawings.
3 Read and make circuit and location diagrams.
4 Perform necessary calculations and produce lists of materials required.
5 Construct simple geometrical drawings.
6 Measure and mark out materials for installing conduit, trunking and traywork.
7 Transfer information from drawings to the installation.

6 Installation Procedures and Techniques

1 Demonstrate knowledge of procedures for the receipt, checking and security of materials and equipment on site.
2 Demonstrate knowledge of day-work reports, diaries and 'as fitted' drawings.
3 State sequence of control gear at supply intake.
4 Describe the methods of protecting installations against overcurrent and earth leakage current.
5 State the factors determining the choice of wiring systems.

6 Select sizes of conductors and cables for lighting, power, cooker or heating circuits.
7 Determine the size of conduit, trunking or traywork to be installed.
8 Select appropriate methods of fixing supports, conduits, trunking, traywork, fittings and accessories to (or within) usual backgrounds and state reasons for selection.
9 Describe the types of support for conduit, trunking or traywork and the methods of allowing for thermal movement.
10 Detail the methods of introducing cable into, and segregating circuits within, conduit, trunking or traywork systems.

7 Testing and Inspection of Installations

1 State the need for testing and inspecting installations.
2 Describe and specify test instruments.
3 Describe test procedures for installations and appliances.
4 Compare test results with installation requirements.

SYLLABUS

236 – PART I CERTIFICATE IN ELECTRICAL INSTALLATION WORK

TECHNICAL STUDIES

Note: the following syllabus will be examined in components 236-1-01, 236-1-02 and 236-1-03 to the extent and in the manner indicated in the objectives.

REFERENCE TO APPROPRIATE IEE REGULATIONS AND BS 3939 SYMBOLS IS ASSUMED THROUGHOUT, BUT THE EXAMINATIONS WILL NOT REQUIRE THEIR MEMORIZATION.

	Craft Theory	Associated Subjects	Practical Activities
	HEALTH AND SAFETY		
1	Safety regulations (including the Electricity (Factories Act) Special Regulations 1908 and 1944 and the Health and Safety at Work etc. Act 1974): purpose and outline introduction.		
2	Electrical safety: means of isolating supplies and testing that circuits are dead; dangers associated with work on or near live plant or systems.	How the human body can become part of an electrical circuit.	Inspect and use an approved test lamp.
3	Safe use of manual and powered tools in workshop and on site. Cables and leads, plugs and socket outlets: importance of competent workmanship and correct connections. Desirability and use of reduced voltage tools and equipment on site. Need for regular inspection of tools and equipment.		Inspect tools and equipment for safe working conditions.

Craft Theory	Associated Subjects	Practical Activities
4 General safety		
(a) Accident prevention: dangers of careless or untidy working; use of safety and protective clothing; dangers associated with unsuitable clothing. Protection of face and eyes.	Reports of dangerous situations and accidents: immediate reporting to summon assistance, and reports for record purposes.	
(b) Access to work: use of ladders and trestles, mobile and fixed scaffolding: provision of handrails and toe boards.	Safe spans for beams and platforms in scaffolding.	Examine ladders and scaffolding for safety in use.
(c) How to lift and handle materials and equipment: correct posture when lifting. Use of lifting and handling equipment. Safe working load.	Principles of levers, inclined planes, jacks and pulleys. Work, load and effort.	Demonstrate safe manual and mechanical movement of loads.
(d) Materials jointing: safety procedures associated with soldering, riveting and crimping.		
5 Fire safety: fire prevention; methods of dealing with fires; types of fire extinguishers and their appropriate uses. Dangers from toxic fumes and smoke.	Conditions required for combustion; their relevance to fire prevention and control and to fire fighting equipment. Special chemicals and equipment for electrical fires. Materials which produce toxic fumes and smoke in fires.	Select, and demonstrate correct use of, fire extinguishing equipment.
6 First aid		
(a) General: extent of first aid to be offered in the event of burns, cuts, bruising, grazing, falling, contact with irritant materials or subjection to toxic fumes and smoke. Importance of seeking qualified assistance.		

	Craft Theory	Associated Subjects	Practical Activities
	(b) Electrical: symptoms and effects of electric shock; need for immediate action to remove victim from contact: dangers involved. Methods of resuscitation: cardiac compression, mouth to mouth, Holger/Nielsen method. Checking for other injuries; immediate treatment to burns.		Practise basic procedures in the event of shock.
	INSTALLATION CIRCUITS		
7	The basic components of a circuit: source of supply, protection, conductors, switch and appliance. The connection of ammeters and voltmeters in circuits.	Potential difference: the volt. Resistance: the ohm. Current: the ampere, coulomb. Ohm's law, simple calculations. Heating, magnetic and chemical effects of an electric current.	Connect up simple circuits to investigate relationship between listed electrical units of measurement. (Emphasis on correct arrangement of ammeter and voltmeter).
8	Sources of supply: d.c. and a.c.; standard voltages up to 11 kV. Concept of graded protection for circuits by fuses and circuit-breakers.	Magnetic fields due to current-carrying conductors: effect of conductor moving through magnetic field. Principles of simple a.c. and d.c. generators; frequency, maximum and r.m.s. values. Simple three-phase generators; four-wire distribution, single-phase derivation. Star and delta connection of loads. Need for neutral conductor in certain circuits.	Demonstrate line and phase currents and voltages on the three-phase four-wire system.
9	Domestic and industrial services; single-phase and three-phase; balancing of loads. The arrangement of lighting and heating loads in series and parallel.	Series and parallel resistive circuits: simple calculations.	Experiment with resistors or lamps connected in series and parallel to establish current and voltage distribution.

	Craft Theory	Associated Subjects	Practical Activities
10	(a) The rating of electrical appliances. (b) Connection of wattmeters, kilowatt-hour meters and power-factor meters in single-phase circuits.	Power: the volt-ampere, the watt; relationship of the watt to the ampere, volt and ohm. Power factor Energy: the joule, the kilowatt-hour. Simple tariffs. Simple calculations.	Connect wattmeter, voltmeter and ammeter in circuits. Connect kilowatt-hour meter into appliance circuit; read energy consumption.
11	Lighting circuits. Tungsten and fluorescent lamp lighting circuits. Wiring of switches, including two-way and intermediate switches. Special requirements for fluorescent lighting. Stroboscopic effect.	Self-induced e.m.f.; inductance. Basic components of an inductor: inductors in a.c. and d.c. circuits. Electric charge: capacitance and capacitors, voltage rating, series and parallel combinations. Power factor improvement. Application of inductors and capacitors to fluorescent lamp circuits.	Demonstrate the effects of including resistors, inductors and capacitors in a.c. circuits. Wire a fluorescent lamp circuit.
12	Bell, call, alarm and emergency lighting systems. (a) Bell and simple indicator circuits; description and operation of buzzers and indicator boards. (b) Circuitry and operation of fire, call and intruder alarm systems; open and closed circuit systems. Segregation of circuits (including telephone circuits). (c) Maintained and non-maintained emergency lighting circuits. (d) Low-voltage systems and supplies.	Simple transformer actions, double and auto-wound: voltage, current and turns ratio. Simple calculations on ratios. Applications of the electromagnet. Calculations involving voltage, current and resistance in low voltage circuits. Voltage drop on radial subcircuits with distributed loads.	Wire and test circuits for fire, call (simple bell-call system with indicator) and intruder alarm systems. Wire and test simple emergency lighting circuits.

Craft Theory	Associated Subjects	Practical Activities
(e) Secondary cells: their installation and maintenance; simple circuits for charging batteries from rectified supplies.	Lead-acid and alkaline cells: electrolyte, relative density, e.m.f. internal resistance and state of charge. Rectification.	Connect cells in series and parallel. Wire and test a battery charging circuit. Carry out charge and discharge experiments. Wire an appliance.
13 Socket outlet circuits. Radial and ring circuits. (Limited to Appendix 5 of the Regulations, omitting reference to BS 196 and BS 4343). Wiring circuits for		
(a) cooking appliances	Operation of thermostats and simmerstats. Bimetallic strips. Specific heat capacity. Simple calculations relating to heating of water and to efficiency (as efficiency = output/input). Percentage efficiency.	
(b) immersion heaters		
(c) space heating appliances.		
14 Circuits in bathrooms and shower cubicles; special requirements. Types of switches. Shaver units.		
MATERIALS COMMONLY USED IN ELECTRICAL INSTALLATION WORK		
15 Materials used		
(a) as conductors (wire, rod or bar) in electric cables and accessories; reasons for form of conductor.	Conductors and insulators. Resistance: its dependence on dimensions, material and temperature. Resistivity. The ohm. Ohm's law. Simple calculations.	Identify materials and compare them for conduction, insulation and mechanical protection. Compare the resistivity of common conductors. Select materials for given applications.
(b) for insulation in cables, accessories and installations; relative effectiveness and durability		
(c) for sheathing and protecting cables; reasons for particular forms of protection	Mechanical protection.	

Craft Theory	Associated Subjects	Practical Activities
(d) in conduit, trunking, traywork and their supports (e) in jointing and soldering; uses of different solders and fluxes (f) in nuts, bolts, screws, connecting and fixing devices.		
16 Mechanical, physical and thermal properties of materials. Effect of heat; thermal movement and flammability. Cold working; work hardening and annealing.	Temperature; use of thermometers.	Investigate mechanical, physical, thermal and insulating properties of materials. Investigate and correct accidental work hardening of metal sheathing.
17 Damage to which materials are subject in store, transit or installation.	Effect of damp and temperature on properties of materials.	
18 Corrosion, erosion and deterioration to which materials are subject: methods of prevention and inhibition.	Electrolytic corrosion: prevention and inhibition. Corrosion, erosion and oxidation of metals. Degradation, cracking and embrittlement of plastics. Behaviour in use of thermosoftening and thermosetting plastics.	Demonstrate electrolytic action and its corrosive effects.
TOOLS, EQUIPMENT AND WORKING PROCESSES		
19 Conduit: rigid and flexible, metallic and nonmetallic		
(a) The cutting, filing and reaming of all types of conduit.		Select, use and take care of hand and powered tools.
(b) The bending of steel and rigid p.v.c. conduits. Permissible radii of bends. Special precautions with different materials.	Mechanical principles relating to bending machines. Heat sources for bending, and heat transfer.	Bending different types of conduit.
(c) Screw-threading of metallic conduit. Types of thread: terminology. Types and use of stocks, taps and dies.	Allowance for thread length.	Thread metal conduit.

Craft Theory	Associated Subjects	Practical Activities
(d) Connection to running couplers, conduit boxes, bends, elbows, tees and accessories. Provision for earth continuity for all types of conduit. Inspection covers. Locking devices. Connections between flexible and rigid conduit.	Reasons for earth continuity: provision of separate protective conductor with nonmetallic and flexible conduit.	Connect listed components.
(e) Types of adhesive used with p.v.c. conduit.		
20 Tools and equipment used on conduit: selection, care, use and maintenance. Special precautions when grinding tool edges.	Effect of tempering on tools.	
21 Trunking and traywork: metallic and nonmetallic		
(a) The cutting, shaping, forming and filing of trunking and traywork: fabricating special shapes.		Select, use and take care of hand and powered tools.
(b) The cutting and bushing of holes.		Cut and bush holes.
(c) The jointing of lengths of trunking and traywork using rivets, screws, or adhesives.		Make joints and connections.
(d) Connection to ready-made joint-fittings, tees and bends: permissible radii of cable bends. Connection to conduits and equipment: provision for earth continuity.	Sketching of tees and bends and their development.	
22 Tools and equipment used on turning and traywork: selection, care, use and maintenance.		

	Craft Theory	Associated Subjects	Practical Activities
23	Cables: sheathed wiring, flexible cables, mineral insulated cable and p.v.c. s.w.a cable		
	(a) Cutting of cable ends, stripping of protectors and insulators; fitting of sleeves.	Notion of 'short circuit' when insulation is damaged.	Prepare termination of listed cables.
	(b) Shaping of conductors to avoid strain; terminating into fixed equipment appliances and accessories.	Sketch terminal wiring arrangements of lighting accessories, switches and appliances. Sketch of p.v.c. or TRS to conduit entry gland.	
	(c) Tinning cable ends and soldering lugs.	Heat transfer: conduction. Heat sinks.	
	(d) Shaping and dressing mineral insulated cable; effect and correction of work hardening.		
24	Tools and equipment used for cable preparation; selection, care, use and maintenance.		
25	Supports and brackets: fabrication and drilling; selection, care, use and maintenance of tools and equipment.	Sketches of supports and brackets.	Fabricate a purpose-made bracket.
26	The plugging, chasing, lining and sleeving of walls and ceilings to receive screws, supports, conduits, fittings and accessories. 'Making good'.		
	MEASUREMENT AND SETTING OUT IN WORKSHOP AND ON SITE		
27	Measuring equipment: rule, tapes, calipers, cable gauges; scale rule. Selection and use.	Linear measure.	
28	Setting out equipment: spirit level, straight edge, plumb line, centre punch, scriber, compasses and square. Selection and use.		Set out and make an offset in trunking and conduit.

	Craft Theory	Associated Subjects	Practical Activities
29	Interpretation of working drawings and preparation of materials lists and requisitions.	British Standard (BS 3939) symbols used in installation circuit and location diagrams. Reading and interpretation of simple technical data, simple graphs and written instructions.	Prepare circuit and location diagrams.
30	Transfer of information from drawings to installation site.		Given an installation drawing, set out the installation on a simulated site.
31	In-situ measurements for fabrication of trunking, traywork or conduit assemblies; specifying for preformed and prefabricated units, supports and brackets.	Calculations for materials requisitions. Illustration of relative costs of different materials and systems.	Draw and construct a prefabricated unit as specified.
32	Development, measurement and marking out of junctions of trunking with trunking or conduit. Marking position and size of holes to be cut in trunking.	Use of geometrical instruments to bisect a line, construct a right angle, and determine the centre of a given circle from two fixed points.	
	INSTALLATION TECHNIQUES AND PROCEDURES – GENERAL		
33	Recording of receipt and checking of materials: security of materials, appliances, tools and equipment.	Reports of damaged or missing items. Day-work reports, diaries and 'as fitted' drawings.	
34	Importance of protecting work and materials during installation, with particular reference to delicate mechanisms and controls.		
35	Disposition on site of materials, appliances, accessories, tools and equipment for convenience during installation work.		
	INSTALLATION TECHNIQUES AND PROCEDURES – CONSUMER'S SWITCHGEAR		
36	Control of supply to consumer's installation. Sequence of supply authority's and consumer's equipment.	Definition of isolation and control.	

	Craft Theory	Associated Subjects	Practical Activities
37	Types and application of control gear including switchgear, distribution boards, consumer units, circuit-breakers. Circuit identity and warning labels.		
38	Methods of protection against overcurrent; relative merits of semi-enclosed and cartridge fuses, miniature circuit-breakers with thermal and magnetic trips. Rating and fusing factors: classes of overcurrent protection. Correction factor on cable rating. Discrimination of overcurrent protection (simple explanation).	Fusing factor and fusing current. Current and voltage rating.	Test the circuit-breakers, fuses and trips listed.
39	Earth fault leakage protection: earthing systems; earth fault loop impedance measurement. Methods of providing adequate earth leakage protection; selecting the appropriate method.		
40	Use of protective conductors, reason for cross-bonding of services.	Testing and measurement of earth continuity and of earth fault loop impedance.	Conduct tests of earth continuity and earth fault loop impedance.
41	Construction, application and installation of residual current-operated and fault voltage-operated devices; methods of testing.		Test earth leakage devices.
	INSTALLATION TECHNIQUES AND PROCEDURES – WIRING SYSTEMS		
42	Factors determining the selection of types and sizes of trunking, traywork, conduit or sheathed cable to be installed.	Determination of cable and conduit factors, space factors: calculation of percentages. Calculation of circular, square and rectangular cross-sectional areas. Description of flammable, explosive, damp and corrosive situations.	

	Craft Theory	Associated Subjects	Practical Activities
43	Sizes of cables and conductors associated with lighting, heating, socket outlet and cooker circuits. Cable rating, Simultaneous demand and maximum loading of subcircuits.	Voltage drop. Heating effect of current on cables. Use of current carrying capacity tables, correction factors.	Measure voltage drop in subcircuits. Demonstrate overheating of cables.
44	Methods of fixing to walls, ceilings and other usual backgrounds. Distance between supports. Allowance for thermal movement of supported materials. Wiring between buildings.	Linear expansion.	
45	The introduction of cables and wiring into trunking, traywork or conduit. Segregation of circuits.		Demonstrate heating effect of a single a.c. conductor in metal conduit. Undertake a practical installation project.
	TESTING AND INSPECTION OF INSTALLATIONS		
46	Visual inspection of installations, testing of installations. Continuity of ring final circuit conductors, continuity of protective conductors including mains and supplementary equipotential bonding, insulation resistance polarity, earth fault loop impedance, operation of residual current devices and fault voltage operated protective devices.	Insulation resistance of cables in series or parallel and of parallel subcircuits.	Conduct tests on completed installations.
47	Testing of disconnected appliances for insulation resistance and earth continuity.		Conduct tests on disconnected appliances.
48	The test instruments used.	Construction of moving-coil and moving-iron instruments; use on a.c. and d.c. circuits.	

SYLLABUS

236 – PART I CERTIFICATE IN ELECTRICAL INSTALLATION WORK

ASSOCIATED SUBJECTS

Note: the following syllabus lists the topics which appear in the main syllabus against the craft theory topics in relation to which they may be examined at this level. These syllabus topics will be examined to the extent and in the manner indicated by the course objectives in the context of the craft theory and not in isolation.

RELATED SCIENCE

1 The electric circuit; series and parallel. How the human body can become part of an electric circuit.
2 Principles of simple a.c. and d.c. generators; frequency, maximum and r.m.s. values; phase difference. Phase angle and power factor. Simple three-phase systems. Star and delta connections of loads. Need for neutral conductor in certain circuits. Single-phase derivation.
3 Electromotive force, potential difference, current, quantity of electricity, power, energy and resistance. SI units: volt, ampere, coulomb, volt-ampere, watt, kilowatt-hour, joule, ohm; their interrelationship. Ohm's law.
4 Conductors, insulators. Voltage drop and use of tables.
5 Resistance: its dependence on dimensions, material and temperature. Insulation resistance of cables in series or parallel subcircuits. Resistivity.
6 Self-induced electromotive force: inductance; basic components of an inductor; inductors in a.c. and d.c. circuits. Inductors in fluorescent lamp circuits.
7 Electric charge: capacitance and capacitors, voltage rating, series and parallel combinations; capacitors in a.c. circuits. Power factor improvement.
8 Simple transformer actions, double and auto-wound: voltage, current and turns ratio.
9 The heating effect of a current (a.c. and d.c.); heating effects on cables, use of current carrying capacity tables, correction factors; heating elements.
10 The magnetic effect of a current; magnetic fields, induced electromotive force; the electromagnet and its applications.
11 The chemical effect of a current; electrolysis; electrolytic corrosion: its prevention and inhibition.
12 Lead-acid and alkaline cells: electrolyte, relative density, e.m.f., internal resistance and state of charge. Rectification.
13 Earth continuity: reason for its provision of separate protective conductor with nonmetallic and flexible conduit; testing and measurement of earth continuity and earth fault loop impedance.
14 Definition of isolation and control of electrical supply.
15 Fusing factor and fusing current; current and voltage rating.
16 Temperature: use of thermometers.
17 Effect of heat: thermal movement. Operation of thermostats and simmerstats: bimetallic strips. Heat sources for bending metal and effecting joints: heat transfer and heat sinks. Effect of tempering on tools.
18 Effect of temperature and damp on properties of materials. Description of flammable, explosive, damp and corrosive situations. Corrosion, erosion and oxidation of metals. Thermosoftening and thermosetting plastics, their behaviour in use. Degradation, cracking and embrittlement of plastics.

19 Conditions required for combustion. Their relevance to fire prevention and control and to fire-fighting equipment. Special chemicals and equipment for electrical fires. Materials which produce toxic fumes and smoke in fires.
20 Safe spans for beams and platforms in scaffolding.
21 Principles of levers, inclined planes, jacks and pulleys. Work, load and effort.

CALCULATIONS

22 Simple calculations involving relationship of SI units, Ohm's law, series and parallel circuits, transformer ratios.
23 Simple calculations related to the heating of water; efficiency = output/input; percentage efficiency. Specific heat capacity.
24 Calculation of circular, square and rectangular cross-sectional areas. Space factors: calculation of percentages. Determination of cable and conduit factors.
25 Linear measure.
26 Calculations for materials requisitions: illustration of relative costs of different materials and wiring systems.
27 Calculations involving voltage, current, and resistance in low voltage circuits; voltage drop on radial subcircuits with distributed loads.

COMMUNICATIONS

28 Use of geometrical instruments: bisecting a line, constructing a right angle, determining the centre of a given circle from two fixed points.
29 Reading and interpretation of simple technical data, simple graphs and written instructions. British Standard (BS 3939) symbols used in installation circuit and location diagrams.
30 Sketching of tees and bends and their development, terminal wiring arrangements of lighting accessories, switches and appliances, p.v.c. or TRS to conduit entry gland, supports and brackets.
31 Reports of dangerous situations and accidents: immediate reporting to summon assistance and reports for record purposes. Reports of damaged or missing items. Day-work reports, diaries and 'as fitted' drawings.

OBJECTIVES AND SYLLABUS
236 – PART II CERTIFICATE IN ELECTRICAL INSTALLATION WORK
COMMUNICATION AND INDUSTRIAL STUDIES

Note: the objectives indicate in general terms the abilities which the craft student should be able to demonstrate, SUBJECT TO THE LIMITS OF THE SYLLABUS CONTENT, when presented for the Part II Certificate Examination.

	Objectives	Syllabus Content
1	State the purpose of the listed sources of information.	British Standards, British Standard Codes of Practice, IEE Regulations, Factory Acts, Electricity Supply Regulations.
2	State the purpose of a bar chart.	Order of work on new construction and on renovation work. Economy of materials and time.
3	State the purpose of contract documents, specifications and bills of quantities.	Types of contract: main and subcontracts; specifications, bills of quantities; variation orders.
4	Describe good site and job organization.	Site layout, disposition of equipment and materials, site security and control.
5	Describe the need for good industrial relations and list the organizations involved in their maintenance.	Purpose of national and local agreements, contracts of employment, grading schemes. Functions of employers' associations, trade unions and joint industry boards or councils. Procedures for the settlement of disputes; conciliation machinery.
6	Describe the importance of maintaining good customer relations.	Relationship with individual clients and with agents of client companies. Customers with different languages and cultural backgrounds. Methods of consultation (direct or via firm) with customers at all major stages of work.
7	State the purpose of and methods of preparing the listed records.	Purpose and preparation of day-work sheets, job sheets and time sheets. Acceptance of deliveries. Making of reports.
8	Read and interpret architects' drawings and layout, 'as fitted', block, circuit and wiring diagrams.	Reading and preparation of layout, 'as fitted', block, circuit and wiring diagrams; reading of architects' drawings. Methods of projection.
9	Recognize and draw to BS 3939 the symbols listed.	The symbols in wiring diagrams for contacts, push buttons and switches, discharge and filament lamps, plugs, sockets, fuses, circuit-breakers and operating coils, conductors, transformers and machines. The symbols in location drawings for switches, socket outlets, fuses, contactors, distribution boards and meters, clocks, bells, push buttons, indicators and telephone points, lamp outlets, appliances, heaters and thermostats, earths and earthing terminal.
10	Prepare requisitions for small installations from drawings.	Taking-off dimensions and quantities of wiring, equipment and materials required. Preparation of requisitions.

OBJECTIVES

236 – PART II CERTIFICATE IN ELECTRICAL INSTALLATION WORK TECHNICAL STUDIES

The following objectives indicate in general terms the abilities which the craft student should be able to demonstrate, SUBJECT TO THE LIMITS OF THE SYLLABUS CONTENT, when presented for the Part II Certificate Examination.

1 Regulations

1 Apply relevant Factory Acts and IEE Regulations to the appropriate syllabus items.

2 Health and Safety

1 Describe the precautions to be taken when working on or near 'live' equipment.
2 Describe the action to be taken in the event of accident to personnel.
3 Describe reporting procedures.

3 Distribution

1 State standard voltages for distribution up to 11 kV.
2 Describe the three-phase four-wire system of distribution.
3 Describe the need for balancing single-phase loads on three-phase systems.
4 Describe the consumers' distribution systems including switchgear, rising mains, and earthing arrangements.
5 Carry out simple calculations involving (a) voltage, current, kVA, kW, kVAr and kWh on single-phase and three-phase balanced systems, and (b) voltage drop in radial feeders.
6 Show with the aid of diagrams how energy meters, wattmeters, voltmeters and ammeters are connected in single-phase and three-phase four-wire systems.

4 Consumer's Switchgear and Earthing

1 Describe fuse and circuit-breaker characteristics.
2 Describe methods of obtaining discrimination and overcurrent protection.
3 Describe earthing systems.
4 By simple calculation or graphical methods (a) solve simple problems involving resistance, reactance and impedance (b) determine earth electrode resistance and (c) determine earth fault currents and earth leakage voltages.

5 Wiring Systems

1 Describe common wiring systems and their application to various types of installation.
2 State special requirements for construction sites and temporary installations (including reference to BSCP 1017).
3 State special requirements for agricultural and horticultural installations.
4 Describe the effect of the environment (e.g. in boiler-houses, in chemical works) on the choice of wiring system.
5 Carry out simple calculations to determine voltage drops in cables.
6 Carry out simple calculations to select cable sizes.

6 Installation of Machines

1 Describe with the aid of diagrams as appropriate
   (a) the essential parts, the circuits, operation and applications of the motors listed
   (b) the methods of starting and reversing the motors
   (c) the need for power factor improvement and the methods available
   (d) electromagnetic induction and its application to a.c. and d.c. motors and inductors.
2 Carry out simple calculations involving
   (a) the rating of motors and the work done by the load
   (b) rating, kW, kVA and power factors of motors
   (c) current, input, output and efficiency
   (d) determination of the size of power factor improvement equipment (include graphical methods of determination)
   (e) motor speed and back e.m.f.

7 Rectification

1 Describe with the aid of diagrams
   (a) the action of semiconductor diodes
   (b) the use of semiconductor diodes in charging circuits
   (c) the action of thyristors
   (d) the rectification of single-phase alternating current.

8 Installation of Lighting

1 Define luminous flux, illuminance,utilization and maintenance factors and state the related units.
2 State the inverse square and cosine laws and use them in simple calculations.
3 Describe the luminous flux method of calculating the illuminance of a surface and use it for simple cases.
4 Describe the various types of lamp in common use and compare their efficacies and light outputs.
5 State the methods of installing lighting, including the special requirements for discharge lamp circuits.

9 Testing, Inspection and Measurement

1 Describe with the aid of diagrams as appropriate
   (a) the procedures to be followed in testing, inspecting and reporting on an installation
   (b) the purpose and use of the instruments listed
   (c) the methods of measuring insulation and conductor resistance in installations (including protective conductors and earth electrodes)
   (d) methods of measuring earth fault loop impedance and testing earth leakage protective devices
   (e) methods of extending the range of instruments listed
   (f) methods of measuring voltage, current and power supplied to single-phase loads and balanced three-phase four-wire loads (include the use of instrument transformers).
2 Solve simple problems relating to
   (a) the extension of the range of the instruments listed
   (b) the total insulation and conductor resistance of cables in series and in parallel.

SYLLABUS

236 – PART II CERTIFICATE IN ELECTRICAL INSTALLATION WORK

TECHNICAL STUDIES

Note: the following syllabus will be examined in components 236-2-11, 236-2-12 and 236-2-13 to the extent and in the manner indicated in the objectives

	Craft Theory	Associated Subjects	Practical Activities
	REGULATIONS		
1	(To be examined only in associated with relevant syllabus items.) The Electricity (Factories Act) Special Regulations 1908 and 1944 sections 1–13 inclusive and 21, 28 and 29. The IEE Regulations, Definitions, Tables and Appendices as appropriate to the relevant syllabus sections.		
	HEALTH AND SAFETY		
2	Safe working methods.		Demonstrate 'live working' techniques.
3	Action to be taken after accidents (including those involving electric shock).		Demonstrate artificial respiration and resuscitation techniques. Investigate mock accidents and prepare reports on the 'accident' and on the action to be taken.
	DISTRIBUTION		
4	Layout of large installations, rising and ring main distributors.		
5	Three-phase three-wire and four-wire systems; TN-C, TN-S, TN-C-S and TT systems; normal and off-peak supply arrangements.	Three-phase circuits, neutral point earthing, line-to-line and line-to-neutral voltages. Connection of wattmeters, voltmeters and ammeters in three-phase, four-wire systems. KWh, kW, kVA, kVAr and power factor. Calculation of currents in three-phase balanced systems.	Measure line and phase currents and voltages on three-phase, four-wire systems. Measure the power in single-and three-phase balanced systems. Determine the power factor of a single-phase load using wattmeter, voltmeter and ammeter.

Craft Theory	Associated Subjects	Practical Activities
	Calculation of voltage drop in radial distributors.	Improve the power factor of a single-phase circuit using capacitors. Measure currents in a ring main feeding several loads. Measure currents and voltage drop in a radial feeder with several load positions.
CONSUMERS' SWITCHGEAR AND EARTHING		
6 The isolation, control and protective functions of switchgear.	The a.c. series and parallel (two-branch) circuit, resistance, reactance and impedance; simple problems involving R, X and Z. Solution of phasor diagrams and triangles by (a) graphical methods, (b) use of theorem of Pythagoras and (c) use of sine, cosine and tangent.	Measure voltages and currents in an a.c. circuit containing R, L and C.
7 Overcurrent protection; discrimination. Description, uses and limitations of semi-enclosed, cartridge and h.b.c. fuses, miniature and moulded case circuit-breakers. Factors determining the choice of fuses and switchgear; current and voltage ratings.		Investigate and compare the performance of semi-enclosed, cartridge and h.b.c. fuses and miniature circuit-breakers. Represent characteristics on graphs.
8 Earthing systems, earth electrodes, earthing conductor, protective conductors and bonding; earth fault loop impedance and protective conductor resistance; PME (TN-C-S) systems and the need for approval.	Resistance area of earth electrodes; tests for earth electrode resistance and earth resistivity; calculation of test results. Simple calculations of fault currents and earth leakage voltage from the resistance of circuit components.	Measure earth electrode resistance.
WIRING SYSTEMS		
9 The common wiring systems. Earthed concentric wiring systems. Factors affecting choice of system.		Demonstrate the effect of a single a.c. conductor in a steel conduit.

	Craft Theory	Associated Subjects	Practical Activities
10	Special requirements for temporary, construction site, agricultural and horticultural installations, and for flammable and explosive situations. BSCP 1017.		Erect small installations under simulated site conditions.
11	Choice of cable size using current carrying capacity tables; correction factors and allowance for diversity.	Calculation of actual and percentage voltage drop. Relation of millivolts per ampere per metre in tables to Ohm's law.	Select cables for simple radial circuits and compare calculated voltage drop with the measured values.
	INSTALLATION OF MACHINES		
12	Motors: single-phase induction motors, the universal motor, three-phase induction motors, d.c. shunt, series and compound motors and their control gear. The essential parts of motors: stator, rotor, laminations and windings.	Force on a current-carrying conductor in a magnetic field. Production of a rotating magnetic field from a three-phase supply; generation of e.m.f. and force on a conductor in a rotating field; principle of the three-phase induction motor; synchronous speed, rotor speed and slip; cage and slip-ring motors. Production of a rotating magnetic field from a single-phase supply: phase splitting using series resistance and capacitance.	Demonstrate the force on a current-carrying conductor. Wire, run and test the motors listed. Investigate methods of reversing rotation. Determine efficiency of motors.
13	The installation of the motors listed: aligning, coupling and fixing machines in position.		
14	Starting equipment and methods.	'Direct-on', 'star-delta' and 'rotor resistance' methods of starting three-phase motors. Phase splitting method of starting single-phase motors.	Investigate methods of starting motors listed.
15	Control and protection equipment and methods: excess temperature protection; oil dashpot and bimetallic overload devices; undervoltage protection.	Push-button control, local and remote.	

	Craft Theory	Associated Subjects	Practical Activities
16	Applications of the motors listed; load and speed, rating and enclosure, power factor and power factor improvement.	Calculation of capacitance required to improve power factor to unity. Rating, kW and kWA and power factor of motors. Calculation of load current from output, power factor and efficiency. Work done equals force times distance; torque. Calculation of the required output of a motor from load data.	
17	(a) Action of the diode and the thyristor; their use in simple circuits. (b) Rectification of single-phase alternating current by diodes and thyristors.		Investigate circuits using (a) semiconductor diodes (b) thyristors. Investigate circuits for rectifying single-phase alternating current.
	INSTALLATION OF LIGHTING		
18	The installation of metal filament and discharge lighting including electric signs: special requirements for high voltage installations: choice of cable size and types of switch.	Simple consideration of illuminance, luminous flux, utilization and maintenance factors. The inverse square law and cosine law: simple calculations.	Wire and test discharge lamps and circuits. Determine the illumination requirements of a room and compare actual and calculated results. Demonstrate the inverse square and cosine law.
19	Comparison of light sources: description of and use of tungsten filament, high and low pressure mercury vapour and sodium lamps.	Circuit diagrams for discharge lamps; the need for ballast.	
20	Starting devices and circuits.		

	Craft Theory	Associated Subjects	Practical Activities
	TESTING, INSPECTION AND MEASUREMENT		
21	Reasons for and methods of carrying out required tests and inspection on a completed installation: sequence of tests and need for acceptable results. 'Live' testing methods.	Inspection of installations and equipment and preparation of reports.	Inspect and report on an installation. Carry out the prescribed sequence of tests on an installation.
22	Instruments: operation, application and limitations of multimeters, tong testers, phase rotation indicators, ohmmeters, insulation and continuity testers, earth fault loop impedance testers, earth leakage protective device testers and battery-bell/buzzer sets.	Extension of the range of moving-coil and moving-iron ammeters and voltmeters. Measurement of insulation and conductor resistance: combined insulation resistance of a number of subcircuits; total insulation and conductor resistance in series and parallel. Measurement of voltage, current and power input to single-phase and three-phase loads including motors. Principle and use of current and voltage transformers: precautions to be taken.	Investigate the use of the instruments listed. Measure the insulation and conductor resistance of single and combined circuits in series and parallel. Measure the current and voltage in simple series and parallel circuits. Measure the voltage, current and power input to single-phase and three-phase loads with and without instrument transformers.

SYLLABUS

236 – PART II CERTIFICATE IN ELECTRICAL INSTALLATION WORK

ASSOCIATED SUBJECTS

Note: the following syllabus lists the topics which appear in the main syllabus against the craft theory topics in relation to which they may be examined at this level. These syllabus topics will be examined to the extent and in the manner indicated by the objectives, in the context of the craft theory and not in isolation.

RELATED SCIENCE

1 Force on a current-carrying conductor in a magnetic field.
2 Production of a rotating magnetic field from a three-phase supply: generation of e.m.f. and force on a conductor in a rotating field; principle of the three-phase induction motor; synchronous speed, rotor speed and slip; cage and slip-ring motors.
3 Production of a rotating field from a single-phase supply: phase-splitting using series resistance and capacitance.
4 Three-phase circuits, neutral point earthing, line-to-line and line-to-neutral voltages.
5 Direct-on, star-delta and rotor resistance methods of starting three-phase motors.
6 Phase-splitting method of starting single-phase motors.
7 Push-button control; local and remote.
8 Rating, kW, kVA and power factor of motors.
9 Measurement of voltage, current and power input to single-phase and three-phase loads, including motors.
10 Connection of wattmeters, voltmeters and ammeters in three-phase four-wire systems.
11 KWh, kW, kVA, kVAr and power factor.
12 The a.c. series and parallel (two-branch) circuit, resistance, reactance and impedance; simple problems involving R, X and Z.
13 Resistance area of earth electrodes; tests for earth electrode resistance and earth resistivity.
14 Circuits for testing earth fault loop impedance, protective conductor resistance and earth leakage protective devices.
15 Measurement of insulation and conductor resistance; combined insulation resistance of cables in series and parallel.
16 Simple consideration of illuminance, luminous flux, utilization and maintenance factors.
17 Circuit diagrams for discharge lamps; the need for ballast.
18 Principle of current and voltage transformers: precautions to be taken.
19 The extension of the range of moving-coil and moving-iron ammeters and voltmeters.

RELATED CALCULATIONS

20 Calculation of currents in three-phase balanced systems.
21 Calculation of voltage drop in radial distributors.
22 Calculation of test results for earth electrode resistance and earth resistivity.
23 Simple calculations of fault currents and earth leakage voltage from the resistance of circuit components.
24 Relation of millivolts per ampere per metre in tables to Ohm's law.
25 Calculation of actual and percentage voltage drop.
26 Calculation of capacitance required to improve power factor to unity.
27 Calculation of load current from output, power factor and efficiency.

28 'Work done equals force times distance'; torque.
29 Calculation of the required output of a motor from load data.
30 The inverse square law and cosine law: simple calculations.
31 Simple calculations on range extension of moving-coil and moving-iron ammeters and voltmeters.
32 Solution of phasor diagrams and triangles by graphical methods, by the use of the theorem of Pythagoras and by the use of sine, cosine and tangent.

COMMUNICATION OF INFORMATION (See also Communication and Industrial Studies)

33 Inspection of installations and equipment; preparation of reports.

SYLLABUS

236 – ELECTRICAL INSTALLATION WORK – COURSE C

INSTALLATION WORK AND REGULATIONS (236-3-21)

The objectives indicate in general terms the abilities which the student should be able to demonstrate subject to the limits of the syllabus content.

Syllabus	Objectives
1 Regulations.	
Regulations for electrical installations.	Demonstrate knowledge of the practical applications to electrical installation work of the current edition of the Regulations for Electrical Installations and the ability to use this knowledge in electrical installation work.
Electricity (Factories Act) Special Regulations 1908 and 1944. Memorandum on the Electricity Regulations (SHW 928).	Demonstrate knowledge of the Electricity (Factories Act) Special Regulations 1908 and 1944 concerning generation, transformation, distribution and use of electrical energy in premises under the Factories Act 1961.
Electricity Supply Regulations, 1937 (Regulations 22-29 and 32). Explanatory Notes on the Electricity Supply Regulations, 1937 prepared by the Electricity Commissioners.	Demonstrate knowledge of the Electricity (Supply) Regulations in so far as they deal with consumer installations under Regulations 22-29 and 32 and of any regulations concerning consumer installation which may be issued by the Electricity Commissioners in addition to or in substitution for those mentioned above.
British Standard Codes of Practice.	State the need for reference to the appropriate codes of practice when planning and carrying out installation work.
2 Special installations	
(a) Explosive area installation. Recognition of areas exposed to the risk of fire and explosion and the selection of suitable installation techniques.	Identify risks attendant in the installation of petrol and diesel retailing pumps. Recognize the need to conform to local licensing authorities and statutory regulations. Select means of satisfying safety requirements regarding supply wiring to pump, control of supplies to pump lighting and motors.
(i) categories of areas of risk	Draw and explain circuit diagrams for pressurized and pipe ventilated systems.
(ii) types of wiring and apparatus for specific areas of risk	Identify the dangers due to the presence of dust in areas not normally considered to be explosive areas. Describe the special precautions to be observed in installation and maintenance procedures.
(iii) need for special protection against overcurrent	
(iv) need for special protection against earth leakage currents	Identify dangers due to static electricity discharges and simple means of minimizing danger.

Syllabus	Objectives
(v) supplies to portable and transportable apparatus including handlamps, consideration of monitored earth leakage protection.	Outline the risks attendant in hospital operating theatres due to static electricity. State simple ways of minimizing danger.
(vi) techniques to be adopted when installing lighting and power, using steel conduit, mineral insulated cables and armoured cables	
(vii) need for special techniques when inspecting and testing installations	
(viii) intrinsically safe circuits and apparatus	
(ix) segregation, ventilation and pressurization methods of avoiding ignition	
(x) flameproof installations.	
(b) Hazardous area installation. Areas liable to require consideration due to the presence of deleterious conditions, e.g.	Assess the installation techniques to be employed in areas exposed to hazardous conditions.
(i) mines and quarries	
(ii) heavy plant maintenance depots	
(iii) water and sewage plant	
(iv) lighting of public areas (vandalism)	
(v) outdoor lighting and power	
(vi) steelworks, foundries	
(vii) building and construction sites.	
(c) Agricultural and horticultural installations.	State and explain ways of minimizing hazards and risks including
Potential hazards to persons, property and animals from the use of electricity due to the abnormal conditions prevalent in agricultural and horticultural establishments, e.g.	(i) assessment of wiring systems which will withstand such conditions
	(ii) correct selection, siting and use of suitable equipment and cables for specific areas

Syllabus	Objectives
(i) damp and humid atmosphere (ii) mechanical and animal damage (iii) chemical corrosion and erosion (iv) rough usage by electrically unskilled persons (v) rodent and vermin attack (vi) earth leakage currents (vii) electric fences.	(iii) provision of reduced voltage supplies and/or monitored earth leakage protection (iv) special earthing arrangements. Describe the installation of overhead and underground distribution cables on agricultural and horticultural establishments.
(d) High temperature installations.	Identify areas requiring special consideration due to high operating temperature conditions and describe cables and terminations for use in high temperature areas. Describe the effects of high temperature on rotating plant and control gear performance, the use of special enclosures and explain the siting of equipment to avoid defects and premature failure. Describe the effects of high temperatures on luminaires and the use of special enclosures.
(e) Low temperature installations.	Identify areas requiring special consideration due to abnormally low operating temperature conditions. State and describe cables and terminations for use in low temperature areas. Describe the effects of low temperature on rotating plant and control gear performance and use of special enclosures. Describe the effects of low temperature conditions on discharge luminaires and choose suitable tubes/lamps and luminaires.
(f) Corrosive environments.	Identify areas requiring special consideration due to the presence of corrosive atmosphere, liquids and fumes including outdoor installations. Compare relative resistance of normal wiring systems and equipment to deleterious environmental conditions. Identify areas requiring special consideration in the choice of installation systems. Select special installation cables, equipment and techniques to counteract adverse conditions.
(g) Fire alarm systems (BS 5839). Types of circuit call points, warning and supervisory devices.	Describe and explain systems of electrically operated fire alarm systems including (i) simple open circuit (ii) monitored open circuit (iii) closed circuit (iv) monitored closed circuit

Syllabus		Objectives
		Describe and identify types of call point in use, e.g. (internal circuitry omitted) (i) manual break glass (ii) smoke detectors (iii) temperature rise detectors (iv) rate of temperature rise detectors (v) flame detectors. State the factors affecting the siting of call points to afford maximum protection to persons and property. Describe and identify types of warning devices used for fire alarm systems including (i) bells (ii) horns (iii) sirens (iv) warblers (v) visual. State the factors affecting the siting of warning devices to afford maximum coverage of premises. Describe and identify types of supervisory devices incorporated, e.g. (i) zone indicators (ii) supervisory sounders and diversion relays Demonstrate a brief outline knowledge only of telephone links to fire brigade and police and the restricted warning arrangements for hospitals, and public entertainment premises.
	Cables, wiring and power supplies.	Identify and describe types of cable and wiring for use with fire alarm systems and method of installation. Explain the need for reliability of supply (i) exclusive main circuit (ii) standby supplies Describe charging and maintenance requirement for cells. Specify the requirements of servicing for simple fire alarm systems. Draw, read and explain circuit diagrams for simple fire alarm systems.
(h)	Standby supplies. Maintained supplies. Emergency supplies.	Recognize buildings and areas requiring the provision of standby sources of supply to ensure (i) safety of persons (ii) security of goods and premises (iii) maintenance of manufacturing processes (iv) correct working of equipment Describe (i) dual supplies (ii) battery systems (iii) standby generators

Syllabus		Objectives
		Select and describe means of providing supply to essential services section of installation in the event of supply breakdown, e.g. sectionalized bus-bars, separate subdistribution arrangement. Draw circuit diagrams to show transfer arrangement to minimize period of supply interruption, (excluding manufacturers' engine control circuit diagrams).
3 Distribution		
(a)	Supply authority network.	Describe the effects of the characteristics of the supply system on the consumer's installation.
(b)	Consumers' distribution.	Describe methods of distribution to load centres. Describe multi substation systems on sites and in buildings (single and multi-storey). Explain the importance of security of supply, use of ring mains, radial feeders, duplicate bus-bars, means of isolation, balancing of loads and need for discrimination between protective devices. Describe provision for future extension. Describe and show methods of distribution in industrial, commercial and domestic premises, i.e. cables, bus-bar trunking. Demonstrate knowledge of load centres and application of diversity to sub-mains. State factors governing the choice of system.
(c)	Distribution systems.	Describe the construction and state the use of cables for distribution systems up to 11 kV including PILCSTA, PIAS, Consac, Waveconal, split concentric cables. State labour-saving benefits derived from the use of up-to-date techniques in cable installation. Describe the contruction and installation of distribution bus-bar systems, connection of take-off points.
(d)	Distribution equipment.	Describe and show a substation layout. Describe methods of cooling transformers. Demonstrate concept knowledge of the forces released on interrupting heavy fault current. Explain how arc control is achieved in the operation of: semi-enclosed fuses, HBC fuses, moulded case circuit breakers, air circuit breakers, oil circuit breakers – plain and assisted types, vacuum circuit breakers. Demonstrate knowledge of air blast circuit breakers.

Syllabus	Objectives
(e) Protection of distribution.	State applications for current and voltage transformers related to overcurrent and earth leakage protection. State applications of induction overcurrent relays and earth leakage relays, in the tripping circuit of circuit breakers. Explain fault energy levels and the effect of power factor on these.
4 Metering	
(a) Supply authority metering.	Describe metering arrangements for domestic tariffs (normal and off-peak). Describe the use of commercial whole current metering: maximum demand indicators. Describe and state industrial CT metering requirements for consumers' installations to enable the connection of the various types of metering including summation metering.
(b) Consumers' metering.	Draw and describe installation and connection of voltmeters, ammeters, wattmeters including the use of CTs and VTs as instrument transformers.
5 Earthing	
(a) Reasons for earthing.	State the hazards arising from earth leakage currents; shock and fire risks.
(b) Methods of earthing.	Describe and explain earth fault loop impedance. Describe the earth fault loop circuit in relationship to methods of earthing. (i) terminal provided by supply authority connected via a metallic path to system earth (ii) use of earth electrodes (iii) PME terminal provided by supply authority.
(c) Earth leakage protection.	Describe the installation and testing of earth electrodes. Demonstrate knowledge of voltage gradients and step potential of electrodes. Describe earth leakage protection and requirements for the consumers' installation. State the effects of fortuitous earth paths. Describe and explain (i) the earth circuit (ii) bonding (iii) use of overcurrent protective devices (iv) fault voltage operated and residual current devices (v) monitored earthing systems.

Syllabus	Objectives
6 Protection.	
Protection of buildings against lightning. CP 326 1965.	Determine the number of air terminations, electrodes and down conductors required.
Methods of protection against lightning strikes.	Explain use of building structures in lieu of down conductors.
Earthing of protective systems and testing.	Describe bonding of extraneous metalwork to protection system and bonding to main earthing system.
	Explain the need for periodic inspection and recording of results.
	Describe testing the resistance to earth of protection electrodes and measurement of soil resistivity.
7 Corrosion and erosion	
(a) Corrosion and erosion within an electrical installation.	Explain briefly the main causes of corrosion and erosion such as chemical attack, natural atmospheric conditions, moisture, electrolytic action.
	Describe methods of protection (i) selection of suitable materials (ii) careful handling of installation materials and storing (iii) application of protective techniques such as surface finishes, paints, tapes, gaskets and sheaths; need for preventive maintenance.
(b) Cathodic protection of structures and equipment. (This is a specialist function but a knowledge of the principles involved is necessary for those who may be engaged in installing equipment.)	Demonstrate basic knowledge of the theory of cathodic protection, galvanic and impressed current systems.
	Identify zinc, magnesium and aluminium as sacrificial anode materials.
	Describe the effects of corrosive waters on immersion heaters and appropriate preventive measures.
8 Equipment	
(a) Application, installation, methods of starting and control of induction, synchronous and a.c. d.c. motors.	Draw circuit diagrams and describe starting methods including use and operation of control and protective devices.
	Determine cable sizes. Describe applications of these motors including the effects of environment and use of motor enclosures.
(b) Application, installation and methods of control of d.c. power supplies obtained through motor generators and silicon rectifiers.	Describe applications and explain operation of motor-generator and rectifiers.
	Draw and explain control circuits for standby generators, including the use of time delay.
	State installation requirements for rectifiers and generators including mobile units.

Syllabus	Objectives
9 Plant.	
Foundations and frameworks for electrical plant.	Describe fixing requirements for transformers, switchgear and motors.
Installation of plant.	Demonstrate basic knowledge of problems in siting of plant, e.g. vibration, noise levels and leakage of oil.
Methods of handling plant.	Identify and describe correct methods for lifting and moving equipment: safety considerations.
Mechanical transmission of power.	Describe direct drives and belt drives including alignment of pulleys, maximum and minimum spacing of pulleys. Determine belt speed, and pulley speed. Select type and number of belts. Explain use of gear and chain drives. Describe methods of achieving change of speed. State advantages and limitations of each type in respect of the environment.
Maintenance of plant. (With reference to BS 3811 1974 as appropriate.)	Describe maintenance requirements for switchgear, transformers, rotating machines. Describe planned maintenance routines, the use of inspection lists and manufacturers' recommendations.
10 Lighting systems.	
Installation of lighting systems with special consideration of discharge lamps and signs and the associated control gear. Harmonics, cause and effect.	Select and describe suitable luminaires for various situations including office blocks, drawing offices, hospitals, road lighting, stock yards and car parks. Select light source related to the advantages and disadvantages, e.g. incandescent, fluorescent, halogen, mercury vapour, sodium vapour. Explain stroboscopic effect. State the requirements and identify and solve problems associated with high voltage discharge signs. State the effects of harmonics on installations and equipment.
11 Heating systems	
(a) Installation of electric space heating systems (i) direct; radiant and convection (ii) thermal storage: storage radiators and underfloor.	Describe methods of wiring, control and protection of direct and thermal storage installation. Compare the different schemes, stating advantages and disadvantages and explain off-peak tariff arrangements. Demonstrate basic knowledge of heat recovery from lighting systems.

Syllabus		Objectives
(b)	Water heating and steam raising by electrical methods.	Describe and compare domestic and commercial water heaters, with reference to types, ratings, installation problems, temperature control. Describe the electrode water heater with reference to installation and temperature control methods.
(c)	Electric control circuits for heating systems using other fuels.	Draw and explain interconnection of control components (external circuitry only).
12 Cable installations		
(a)	Types of cable for use on systems up to and including 11 kV.	Select suitable cable type to cater for various external influences. Determine conductor cross-sectional area with consideration of load, length, ambient temperature, grouping and class of protection.
(b)	Methods of handling, installation and termination.	Identify and state problems created by mishandling and careless installation techniques. Describe cable termination techniques.
13 Testing and inspection		
(a)	Inspection, testing and reports on electrical installations. Commissioning of new installations. Diagnosis, location and remedying of faults including use of Murray and Varley loops.	Describe methods of visual inspection and electrical testing of installations relating to fault finding and periodic inspection and testing. State precautions when dealing with special installations as mentioned in syllabus section 2 and those installations incorporating electronic components.
(b)	Inspection, testing and reporting on the condition of electrical machines and associated equipment. Recommissioning of machines and equipment.	Describe procedures for dealing with common faults likely to be encountered in electrical installation work involving a.c. and d.c. motors and generators, transformers, contactors and protective devices. State routine testing and reporting procedures. Describe tests and procedures in the recommissioning of machines and equipment.
14 Estimating.		
Estimation of materials, plant and labour required for simple installations. Consideration for estimating purpose of problems associated with installations in various types and phases of building construction.		Assess labour, materials and plant based upon information from drawings, specifications or measurements taken on site and identify the problems concerned with access for delivery of materials, special handling plant for off-loading and siting of items of equipment, e.g. transformer, switch and control panels.

Syllabus	Objectives
15 Planning. Introduction to the programming of an installation and of the resources needed to carry it out. Preparation and use of bar charts; reading of networks; utilization of resources.	Demonstrate knowledge of the need to coordinate installation contract with main contract and other trade's subcontracts. Explain the need for economical use of available labour and plant resources through planned utilization. Recognize the need to plan phased deliveries of materials to suit site conditions and contract progress.
16 Site supervision. Site diaries and records of variations, daywork and site instructions. Introduction to specifications, related drawings, bills of quantities and conditions of contract. Record drawings.	Describe and use site records and procedures. Explain the importance of detailed records of all site instructions, deliveries and occurrences. Demonstrate knowledge of the documents to be able to discern, prove and advise the employer of departures from the installation as tendered. Show an understanding of constructional drawings, British Standard electrical symbols, associated symbols and annotation conventions to sketch/amend drawings so that 'as installed' drawings can be prepared.
Safety on site. Relationship of the Health and Safety at Work Act (HASWA) and other safety and health legislation statutes and regulations applicable to the construction industry. Legal obligations of employees and employers.	Demonstrate a knowledge of the background to the 1974 legislation as an enabling instrument. Recognize the notion of 'duty of care', in the context of the 1974 legislation, as a social obligation. Show knowledge of legal requirements of both employees and employers for the avoidance of hazards to life and health. Recognize welfare provision and the need for specialized advice on specific hazards.
Methods of dealing with and reporting accidents. Labour relations. Employment Protection Act, Trade Union and Labour Relations Act, Race Relations Act, Sex Discrimination Act, Industrial Agreements. Employment as a two-party contract within the constraints of employment legislation.	Demonstrate a knowledge of purpose of employment legislation and industrial agreements sufficient for the need for careful selection, recruitment, engagement, disciplinary and dismissal procedures to be appreciated.

SYLLABUS
236 – ELECTRICAL INSTALLATION WORK COURSE C
ELECTRICAL SCIENCE (236-3-22)

The objectives indicate in general terms the abilities which the student should be able to demonstrate subject to the limits of the syllabus content.

	Syllabus	Objectives
1	Electromagnetic theory. Electromagnetism, B/H curves, iron losses, force on a conductor in a magnetic field.	Explain electromagnetic theory in relation to its application to machines, contactors, relays and transformers. State that flux depends upon ampere-turns and describe the physical properties of the magnetic circuit including the effect of air gaps, their necessity and where they should be avoided.
	Electromagnetic induction, self/mutual. Growth and decay of current in an inductive circuit. Energy stored. Discharge resistors.	Explain rate of change of current. Describe the effects of frequency and flux density on hysteresis and eddy current losses. State the precautions to be observed when using single core cables on a.c. Demonstrate knowledge of inductive effect of one circuit upon another, radio frequency interference and its suppression. Graphically develop L/R growth and decay curves. Describe the use of voltage dependent resistors and 'flywheel' diodes.
2	Electrostatic theory. Capacitors in series and parallel, energy stored. Need for discharge of capacitors and cables. Charge and discharge curves of a capacitor. Voltage and current changes in capacitance-resistance circuits. Capacitance of cables. Industrial uses of capacitors. Static electricity: causes and method of control.	State charge as voltage x capacitance. Graphically develop C-R growth and decay curves. Demonstrate use as a timing circuit. Explain dielectric strength; voltage limits. State the need for observation of polarity.
3	Circuit theory. AC and d.c. series and parallel-circuit calculations. Kirchhoff's laws. Solution of simple bridge circuits for balanced conditions. Circuits containing resistance, capacitance and inductance. Resonance. Power factor. 3-phase circuits, star and delta connections. Line and neutral currents with balanced and unbalanced loads. Calculations on 3-phase power and kVA. Phasor diagrams and their use in the solution of problems.	Perform circuit calculations numerically and/or by graphical phasor addition as appropriate, for series and parallel circuits. State and apply Kirchhoff's laws to simple circuits including distributors and ring mains. Draw and describe the 3-phase circuits listed including the use of phasor diagrams. Solve problems related to 3-phase circuits numerically or by phasor addition. 3-wire star unbalanced loads should not be included in power calculations.

Syllabus	Objectives
4 DC machines. Simple theory of motors and generators. Elementary treatment of armature reaction and commutation. Shunt, series and compound arrangements. Characteristics, efficiency and applications.	Draw circuit diagrams and perform calculations on torque, input, output and efficiency, (calculations involving magnetic flux and number of armature conductors not included). Demonstrate knowledge of critical field resistance and speed on qualitative basis only. Explain commutation related to correct adjustment of brush position and state methods of achieving good commutation. State applications of series, shunt and compound motors and generators. Detail procedures to carry out commissioning tests.
5 Transformers. Double wound and auto-transformers; copper and iron losses. Regulation, percentage impedance, voltage drop. Short circuit currents resulting from an installation fault. Standard terminal marking and permissible parallel arrangements	Describe types of transformers in common use, including construction and cooling. Use graphical or approximate methods of calculating regulation. Calculate installation fault currents and dependence on transformer regulation. Calculate transformer efficiency and regulation.
6 AC machines. Production of a rotating field by 3-phase supply. Effect of supply frequency on speed of rotating field. The 3-phase cage induction motor. Double cage and pole changing motors. The 3-phase wound rotor slip ring induction motor. Production of simulated 'rotating field' in single phase motors. Capacitor start cage induction motor. Split-phase cage induction motor. Shaded pole cage induction motor. 'Universal' commutator motor.	Provide qualitative description of rotating field with the aid of simple diagrams of winding arrangements of stator and rotor. Describe the effects of connecting stator windings in star or delta and of phase reversal in one winding. Compare and explain speed/torque/current characteristics of cage and wound rotor induction motors with varying field arrangements. Describe the effect of double cage rotor on starting torque and current. Demonstrate knowledge of the concept of frequency variation to achieve speed control. Describe the effect of overloading or stalling on currents in windings. Define slip frequency and state its effect on iron losses. Describe copper and iron losses and relate these to efficiency. Distinguish between total torque developed and shaft torque. Compare the types of single-phase motors in general use, including starting characteristics of capacitor start, capacitor start and run, split phase and shaded pole.

Syllabus	Objectives
7 Synchronous machines. The synchronous motor and alternator. Power factor improvement by synchronous motors.	Describe the basic constructional feature of the synchronous motor and alternator. Explain the effect of varying excitation and mechanical input to an alternator. Describe methods of synchronizing 3-phase alternators and the modification necessary to make synchronous motors self starting. Explain the effect of varying excitation and load of a synchronous motor to achieve power factor improvement.
8 Motor starting and control systems.	Demonstrate knowledge of starting currents and torques due to different methods of starting and the effect of these on the supply system.
Revision of starting methods and speed control for d.c. machines.	Describe starting methods including the use of the face plate starter, contactor, field and armature regulators. State the functions of the various components of the basic Ward-Leonard system and describe the operations of the circuit. Explain the intermittent rating of starters and continuous rating of field rheostats.
Revision of starting methods and speed control for single-phase and 3-phase induction motors.	Describe starting methods including direct-on-line, star-delta, wound rotor and autotransformer. Describe speed control using pole changing, frequency changing, rotor resistance and thyristor voltage regulation methods.
Motor protective systems and overall control systems.	Use block diagrams as an introduction to overall control systems. Describe and explain supervisory and sequence control of multi-drive units.
9 Measurement (a) Instruments.	Describe principles of operation (not construction) of the types of instruments used to measure voltage, current, power, resistance, (including bridge-type instruments), speed, temperature, frequency and power factor.
(b) Uses and applications of analogue and digital instruments (i) Permanently installed instruments, including associated external circuits and equipment.	Describe uses and applications. With the aid of sketches describe the use of voltage transformers, current transformers, including selector switches. Demonstrate knowledge of ratio and burden (load) in correct selection of voltage and current transformers.

Syllabus		Objectives
	(ii) Portable instruments. Multi-range meters, 'clip-on' ammeters, continuity testers, insulation testers and earth loop impedance testers. Instruments for testing the resistance of earth electrodes and instruments for testing the operation of residual current and voltage operated protective devices. Pyrometers and tachometers.	Describe uses and applications of the listed instruments. Describe and use the two wattmeter method of determining power and power factor (without proof of formula).
10 AC distribution. Single and 3-phase systems up to 11 kV.		Describe 2, 3 and 4 wire circuits. Explain the need for balance of loads on a 3-phase system and correct distribution of single phase loads on a 3-phase circuit. Demonstrate knowledge of the applications of overcurrent and earth leakage protective devices. Describe and explain discrimination and grading of protective devices.

11 Electronics

The aim of this section is to give a basic understanding of electronic applications in electrical installation work. It is intended that much of the content will be taught within a workshop/laboratory environment.

Use of the cathode-ray oscilloscope.	Demonstrate knowledge of the oscilloscope as a tool for investigation of circuit behaviour. Determine time, amplitude and frequency from trace measurements.
Operation and applications of transducers: light dependent resistors, photodiodes, phototransistors, strain gauge and piezoelectric pressure transducers, thermocouples, thermistors, variable capacitors and resistors.	Describe briefly the operational function of the listed devices (characteristics are not required). State typical applications.
Elementary treatment of diodes, transistors, zener diodes, diacs, triacs and thyristors.	Describe briefly the operational function of the listed devices (characteristics are not required). State voltage, current and temperature limits. Describe the effects of transients and thermal runaway.

Syllabus	Objectives
Packaging of discrete components and integrated circuits. Printed circuit boards.	Describe briefly the packages used for active components including ICs. State the factors to be observed when replacing components on printed circuit boards.
DC power supplies.	Draw circuit diagrams and describe the operation of half-wave, full-wave and bridge circuits including smoothing circuits. Describe simple zener diode voltage stabilizing.
Amplifiers.	Explain operational function of amplifiers treated as a black box. Describe relationship between input, output and gain.
Signal sources: signal and pulse generators.	Describe and use signal sources as a tool for investigation of circuit behaviour. Explain in simple terms mark-space ratio.
Logic gates and circuits.	Describe AND, OR, NAND, NOR and NOT gates and use truth tables to illustrate function. (Logic circuits restricted to two inputs per gate and up to four gates.)
Control circuits.	Demonstrate knowledge of methods of gating thyristors and triacs; explain amplitude, phase angle, pulse and burst firing. Describe methods of isolating gates, e.g. 3-phase control. State precautions necessary when controlling reactive loads, e.g. discharge lighting and motors. Explain the need for observance of manufacturer's specifications in respect of current, voltage, temperature and polarity. Describe remote control devices, e.g. infrared and sonic beams.
Testing of electronic and semiconductor devices.	State types of test instruments and their uses. Describe the effects of test instruments when applied to circuits. Explain simple go/no go tests on electronic components. Relate sensitivity, polarity and voltage limitations to the use of multimeters for testing electronic components.
12 Utilization of electric power. Motors. Calculation of electrical/ mechanical power requirements.	Determine electrical power required to carry out various mechanical tasks, e.g. hoists, lifts, pumps.
Heating. Power requirements for heating loads. Selection and siting of the most suitable forms of electrical heating and their associated controls.	Determine electrical power requirements (i) by calculation of steady state heat loss from a heated building using recommended design criteria (ii) for water heating.

Syllabus	Objectives
Lighting. Light sources; filament and discharge lamps and associated luminaires. Principles of lighting design.	State and apply terms used in illumination. Calculate illumination by (i) inverse square law and cosine law (ii) luminous flux method. Describe the cause and effect of glare (glare index NOT to be used in calculation).
Tariffs. Basis and elements of various tariffs in common use.	Briefly explain tariffs and load demand curves. State advantages and limitations of flat rate, block two-part, maximum demand and off-peak tariffs. Calculate costs using typical Electricity Board tariffs.
Power factor. Effect of loads with low power factor; advantages of power factor improvement; power factor improvement calculations.	Describe the importance and effect of power factor in the rating of electrical machines and equipment. Explain the economics of power factor improvement. Compare and equate the merits of individual and group improvement methods.

236 – ELECTRICAL INSTALLATION WORK COURSE C LABORATORY/WORKSHOP ACTIVITIES

The exercises listed are intended to illustrate the principles included in the Course C Installation Work and Regulations and Electrical Science syllabuses and to promote an understanding of the reasons for correct practice.

The exercises should cover a complete course but will need to be adjusted in accordance with the scheme of work used.

Confirmation that a student's programme of laboratory/workshop activities has been completed satisfactorily will be required on individual project marksheets.

1 Investigation into effects of parallel earth paths (e.g. using simulation panel).
2 Layout wiring requirements and connection of an electrical control system for heating.
3 Diagnostic fault finding on installations.
4 Murray loop test and Varley loop test for cable fault-location.
5 Diagnostic fault finding on a.c. and d.c. machines and associated control gear.
6 Magnetization characteristics of a d.c. generator.
7 Charge and discharge curves (capacitor).
8 Current in a neutral (3-phase unbalanced load) and the effect of a broken neutral.
9 Verification of Kirchhoff's laws.
10 RLC series and parallel a.c. circuits.
11 Resonance (i.e. variable frequency AND variable reactance).
12 Efficiency and regulation of a transformer.
13 Load tests on d.c. generators, d.c. motors and on induction motors.
14 Load tests on an alternator and on a synchronous motor.
15 Synchronizing an alternator on to 'live' bus-bars.
16 Power factor improvement using synchronous motor.
17 3-phase power factor improvement.
18 Layout, wiring requirements and connection of sequence control for motors.
19 Use of CTs and VTs.
20 Two-watt meter method (3-phase power).
21 Use of Wheatstone bridge.
22 Installation and commissioning of residual current and fault voltage operated protective devices.
23 Inverse square and cosine laws of illumination.
24 Investigation of control, operation and output of MV, SV and fluorescent lamps and circuits.
25 Plotting the 'polar' curve for a luminaire.
26 Use of the cathode-ray oscilloscope to determine the amplitude and frequency of alternating voltages.
27 Use of LDRs for automatic lighting systems and of thermocouples for measurement of temperature.
28 Introduction to use of manufacturer's data to identify connections to semiconductor devices.
29 Construction of a simple zener diode stabilizing circuit.
30 Investigation of the operation of a simple amplifier to determine amplifier gain.
31 Production of a simple astable multivibrator to demonstrate the relationship between capacitance, and resistance and the mark-space ratio.
32 Construction and testing basic logic circuits.
33 Construction and investigation of a phase controlled lamp dimming circuit.
34 Use of test instruments to perform simple tests on semiconductor devices.