Foreword

This booklet contains OCR’s Advanced Subsidiary (AS) and Advanced GCE (A Level) Electronics specifications for teaching from September 2000.

The Advanced Subsidiary is assessed at a standard appropriate for candidates who have completed the first year of study of a two year Advanced GCE course i.e. between GCSE and Advanced GCE. It forms the first half of the Advanced GCE course in terms of teaching time and content. When combined with the second half of the Advanced GCE course, known as ‘A2’, the Advanced Subsidiary forms 50% of the assessment of the total Advanced GCE. However, the Advanced Subsidiary can be taken as a ‘stand-alone’ qualification. A2 is weighted at 50% of the total assessment of the Advanced GCE.

The first year of certification of the OCR Advanced Subsidiary in Electronics is 2001.

The first year of certification of the OCR Advanced GCE in Electronics is 2002.

In these specifications the term module is used to describe specified teaching and learning requirements. The term unit describes a unit of assessment.

Each teaching and learning module is assessed through its associated unit of assessment.
These specifications meet the requirements of the *Common Criteria* (Qualifications and Curriculum Authority, 1999), the *GCE Advanced Subsidiary and Advanced Level Qualification-Specific Criteria* (QCA, 1999) and the relevant Subject Criteria (QCA, 1999).
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OCR ADVANCED SUBSIDIARY GCE IN ELECTRONICS (3826)

OCR ADVANCED GCE IN ELECTRONICS (7826)

Specification Summary

Outline

These Advanced Subsidiary GCE and Advanced GCE specifications aim to provide an introduction to and thorough grounding in electronics. They are designed around a systems approach to electronics which introduces a wide range of transducers, and input, output and processing systems and encourages a practical, problem-solving approach. Project work allows the development of skills and the application of knowledge in the solution of a practical problem. The specifications aim to give an introduction to the electronics involved in modern communication and control systems.

Specification Content

Advanced Subsidiary

Foundations of Electronics (Module 2526)
system components; fundamentals of circuit building; operational amplifier systems; digital systems.

Signal Processing (Module 2527)
negative feedback; positive feedback; Boolean algebra and synchronous counters; analysis of systems.

A2

Communication Circuits (Module 2529)
resonant circuits; transistor circuits; analogue communication systems; television systems; digital communication systems.

Control Circuits (Module 2530)
d.c. servo control systems; triacs; logic and memory systems; microprocessor systems.
Scheme of Assessment

The Advanced Subsidiary forms 50% of the assessment weighting of the full Advanced GCE. Advanced Subsidiary GCE is assessed at a standard between GCSE and Advanced GCE and can be taken as a stand-alone qualification or as the first half of the full Advanced GCE course.

Assessment is by means of 3 units of assessment for Advanced Subsidiary GCE and 6 units of assessment for Advanced GCE.

Advanced Subsidiary GCE
Candidates take Units 2526, 2527 and 2528.

Advanced GCE
Candidates take Units 2526, 2527, 2528, 2529, 2530 and 2531.

Units of Assessment

<table>
<thead>
<tr>
<th>Unit</th>
<th>Level</th>
<th>Name</th>
<th>Mode of Assessment</th>
<th>Duration</th>
<th>Weighting %</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>AS</td>
<td>Advanced GCE</td>
</tr>
<tr>
<td>2526</td>
<td>AS</td>
<td>Foundations of Electronics</td>
<td>Written Examination</td>
<td>1 hour 30 mins</td>
<td>40%</td>
<td>20%</td>
</tr>
<tr>
<td>2527</td>
<td>AS</td>
<td>Signal Processing</td>
<td>Written Examination</td>
<td>1 hour 15 mins</td>
<td>30%</td>
<td>15%</td>
</tr>
<tr>
<td>2528</td>
<td>AS</td>
<td>Electronics Project 1</td>
<td>Coursework</td>
<td>-</td>
<td>30%</td>
<td>15%</td>
</tr>
<tr>
<td>2529</td>
<td>A2</td>
<td>Communication Circuits</td>
<td>Written Examination</td>
<td>1 hour 30 mins</td>
<td>-</td>
<td>20%</td>
</tr>
<tr>
<td>2530</td>
<td>A2</td>
<td>Control Circuits</td>
<td>Written Examination</td>
<td>1 hour 15 mins</td>
<td>-</td>
<td>15%</td>
</tr>
<tr>
<td>2531</td>
<td>A2</td>
<td>Electronics Project 2</td>
<td>Coursework</td>
<td>-</td>
<td>-</td>
<td>15%</td>
</tr>
</tbody>
</table>

Question Paper Requirements

Advanced Subsidiary

The question papers for Units 2526 and 2527 consist of a variable number of structured questions. All the questions are compulsory.

A2

The question papers for Units 2529 and 2530 consist of a variable number of structured questions. All the questions are compulsory.

40% of the marks in Units 2529, 2530 and 2531 are awarded for synoptic assessment.
Coursework requirements

There is one coursework unit in AS (Unit 2528) and one in A2 (Unit 2531), in each of which candidates complete a project. Each coursework project should be distinct and take between 15 and 20 hours of laboratory time. Projects are marked by the teacher, internally standardised in the Centre and externally moderated by OCR.

Key Skills

Key Skills signposting appears in three sections of OCR specifications:

1. Key Skills Coverage – the matrix aids curriculum managers in mapping the potential Key Skills coverage within each OCR Advanced Subsidiary/Advanced GCE specification.

2. Specification Content (section 5) – the specific evidence references enable subject teachers to identify opportunities for meeting specific Key Skills evidence requirements within the modules they are delivering.

3. Appendix A – provides guidance to teachers in trying to identify those parts of their normal teaching programme which might most appropriately be used to develop or provide evidence for the Key Skills signposted.

These specifications provide opportunities for the development of the Key Skills of Communication, Application of Number, Information Technology, Working With Others, Improving Own Learning and Performance and Problem Solving.

Through classwork, coursework and preparation for external assessment, candidates may produce evidence for Key Skills at Level 3. However, the extent to which this evidence fulfils the requirements of the QCA Key Skills specifications at this level will be dependent on the style of teaching and learning adopted for each module. In some cases, the work produced may meet the evidence requirements of the Key Skills specifications at a higher or lower level.

Throughout section 5 the symbol is used in the margin to highlight where Key Skills development opportunities are signposted. The following abbreviations are used to represent the above Key Skills:

- C = Communication
- N = Application of Number
- IT = Information Technology
- WO = Working with Others
- LP = Improving Own Learning and Performance
- PS = Problem Solving

These abbreviations are taken from the QCA Key Skills specifications for use in programmes starting from September 2000. References in section 5 and Appendix A, for example IT3.1, show the Key Skill (IT), the level (3) and subsection (1).

Centres are encouraged to consider the OCR Key Skills scheme to provide certification of Key Skills for their candidates.

Key Skills Coverage

For each module, the following matrix indicates those Key Skills for which opportunities for at least some
coverage of the relevant Key Skills unit exist.

<table>
<thead>
<tr>
<th></th>
<th>Communication</th>
<th>Application of Number</th>
<th>IT</th>
<th>Working with Others</th>
<th>Learning Performance</th>
<th>Problem Solving</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level 3</td>
<td>Level 3</td>
<td>Level 3</td>
<td>Level 3</td>
<td>Level 3</td>
<td>Level 3</td>
</tr>
<tr>
<td>Module 2526</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Module 2527</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Module 2528</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Module 2529</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Module 2530</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Module 2531</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

**GNVQ overlap**

These specifications offer the following overlap opportunities with Advanced GNVQ specifications:

Engineering: Unit 7266: Electrical Principles and Unit 7267: Digital Electronic Principles
1 Introduction

These OCR specifications lead to qualifications at Advanced Subsidiary GCE and Advanced GCE in Electronics. Candidates take three units for Advanced Subsidiary and a further three for A2. Advanced Subsidiary and A2 combined constitute the full Advanced GCE specification. There is coursework in both Advanced Subsidiary and A2.

The emphasis throughout the course is on a systems (linked device) approach, i.e. candidates should be made aware that a complex system may be usefully sub-divided into a number of constituent sub-systems each of which may, in turn, be further broken down into more basic components/circuit elements (Modules 2526 and 2527). By specifying the input characteristics of each system and by understanding how each component or sub-system affects, or is affected by, the other constituent parts, the behaviour of the system as a whole may be understood. For this reason, the specifications have been set out in a hierarchical order from basic circuit elements (Module 2526), through systems of increasing scale or complexity to a complete microprocessor system (Module 2530). The specifications also summarise those basic principles of the electrical behaviour and properties of circuits and their elements which are considered necessary for a sound understanding of the systems approach.

The hardware used for assembling electronic systems is undergoing rapid change and development; it is important, therefore, that candidates should learn the principles underlying the interactions between sub-systems rather than the details of the technology behind individual sub-systems. It is obviously impossible to teach electronics without using some hardware but candidates should become aware that different technologies can build systems with similar overall behaviour using devices with different characteristics, for example, CMOS and TTL logic gates. By concentrating on system principles rather than on technologies, the course will stand candidates in good stead irrespective of whatever changes in technology the future has to offer. It is assumed that the course will be based on practical work.

The specifications have been written without assuming that candidates will be taking Advanced level Mathematics or Physics in conjunction with the course. However, prior acquaintance with relevant parts of GCSE Mathematics and Science specifications would be an advantage. It is assumed that any tuition needed to cope with the mathematics implied by the specifications would be provided to supplement the basic teaching of the specifications.

1.1 Certification Title

These qualifications are shown on a certificate as

- OCR Advanced Subsidiary GCE in Electronics.
- OCR Advanced GCE in Electronics.
1.2 Language

These specifications and associated assessment materials are available in English only.

1.3 GNVQ overlap

These specifications offer the following overlap opportunities with Advanced GNVQ specifications:

Engineering: Unit 7266: Electrical Principles and Unit 7267: Digital Electronic Principles

1.4 Exclusions

Candidates who enter for this Advanced Subsidiary GCE specification may not also enter for any other Advanced Subsidiary GCE specification with the certification title Electronics in the same examination series.

Candidates who enter for this Advanced GCE specification may not also enter for any other Advanced GCE specification with the certification title Electronics in the same examination series.

Every specification is assigned to a national classification code indicating the subject area to which it belongs.

Centres should be aware that candidates who enter for more than one GCE qualification with the same classification code will have only one grade (the highest) counted for the purpose of the School and College Performance Tables.

The classification code for these specifications is 1730.

1.5 Code of Practice Requirements

These specifications will comply in all respects with the revised Code of Practice requirements for courses starting in September 2000.
2 Specification Aims

The aims of these Advanced Subsidiary GCE and Advanced GCE specifications are to encourage candidates to:

- develop and sustain an interest in and an enjoyment of electronics and its applications;
- develop an awareness and an understanding of the social and economic implications of electronics;
- develop knowledge and understanding of the principles of electronics which are desirable in a technologically-based society;
- develop an appropriate body of knowledge for those not studying the subject beyond this stage, which will also serve as a foundation for more advanced studies in electronics;
- develop the skills of observation, experimentation and the processing and interpretation of data;
- apply qualitatively and quantitatively their knowledge and understanding of electronic principles;
- apply a logical approach to the analysis and synthesis of complex systems;
- develop the practical skills associated with the design, construction and testing of electronic systems;
- foster relevant communication skills.

2.1 Spiritual, Moral, Ethical, Social and Cultural Issues

Through the study of these specifications, candidates should develop their awareness of the economic and social consequences of developments in electronics. They could, for example, become more aware of the financial consequences of technological developments, the cost of training and the implications for employment. This aspect of electronics is referred to in the assessment criteria for the coursework projects (see Appendix D).

Candidates should also develop a sense of intellectual satisfaction through their study of the specification content and through their perseverance and success in practical work.

2.2 Environmental Education, the European Dimension and Health and Safety Issues

Through the study of these specifications, candidates should develop their awareness of the environmental, European dimension and Health Education issues in electronics. They could, for example, become aware of the Health and Safety requirements of electronic products within the European Community. The safety aspect of electronics is addressed in one of the Assessment
Objectives (AO3 Experiment and investigation).

2.3 Avoidance of Bias

OCR has taken great care in the preparation of these specifications and assessment materials to avoid bias of any kind.
3 Assessment Objectives

The assessment objectives AO1, AO2 and AO3 apply to both Advanced Subsidiary GCE and Advanced GCE. AO4 applies only to the A2 part of the Advanced GCE course.

AO1 Knowledge with understanding

In the context of the defined specification content, candidates will be expected to demonstrate knowledge and understanding of:

- the transfer characteristics of the components mentioned in the specification and be able to state them;
- the use of the transfer characteristics to describe in qualitative and quantitative terms the behaviour of a component when it is part of an electronic system;
- the small-scale systems listed in the specification, identify them, and state their behaviour;
- the behaviour of an electronic system or component and describe this by a variety of means such as graphs, algebra and words;
- circuit diagrams and be able to draw them in a clear and logical fashion, using standard circuit symbols and conventions;
- the behaviour of small-scale systems and be able to explain these by referring to the transfer characteristics of their basic components and how they interact with each other;
- appropriate applications of electronics and the social, economic and environmental implications of electronics, related applications, developments or phenomena.

AO2 Application of knowledge and understanding, synthesis and evaluation

Candidates will be expected to:

- analyse a complex electronic system by recognising it as a set of mutually interacting sub-systems and, by applying that to the behaviour of those sub-systems, describe and explain the behaviour of a whole system;
- analyse machine code programs which make microprocessor systems perform electronic functions;
- apply the principles of electronics outlined in the specification to calculate/describe how information is processed by an electronic system;
- describe the steps involved in the design, assembly and trouble-shooting of a complex electronic system;
- organise and present information, ideas, descriptions and arguments clearly and logically, taking into account their use of grammar, punctuation and spelling;
- synthesise electronic systems which execute a stated function, using basic components and small-scale systems;
- synthesise machine code programs which will make a microprocessor system execute a stated function.
AO3 Experiment and investigation

Candidates should be able to:

- devise and plan experimental activities, selecting appropriate components;
- demonstrate safe and skilful practical techniques;
- make observations and measurements with appropriate precision and record these methodically;
- interpret, explain, and evaluate the results of experimental activities, using knowledge and understanding of electronics and to communicate this information clearly and logically in appropriate forms eg prose, tables and graphs, using appropriate specialist vocabulary;
- assemble a complex system using basic components in a systematic and appropriate way;
- fault-find an assembled electronic system;
- use IT to analyse data and to present findings in the project reports.

AO4 Synthesis of knowledge, understanding and skills

Candidates should be able to:

- bring together principles and concepts from different areas of electronics and apply them in a particular context, expressing ideas clearly and logically and using appropriate specialist vocabulary;
- use the skills of electronics in contexts which bring together different areas of the subject.

The assessment objectives are weighted as follows:

<table>
<thead>
<tr>
<th></th>
<th>Advanced Subsidiary</th>
<th>A2</th>
<th>Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GCE</td>
<td></td>
<td>GCE</td>
</tr>
<tr>
<td>AO1</td>
<td>52%</td>
<td>24%</td>
<td>38%</td>
</tr>
<tr>
<td>AO2</td>
<td>18%</td>
<td>16%</td>
<td>17%</td>
</tr>
<tr>
<td>AO3</td>
<td>30%</td>
<td>20%</td>
<td>25%</td>
</tr>
<tr>
<td>AO4</td>
<td>-</td>
<td>40%</td>
<td>20%</td>
</tr>
</tbody>
</table>
3.1 Specification Grid

The relationship between assessment objectives and the units of assessment is shown in the specification grid below:

<table>
<thead>
<tr>
<th>Unit</th>
<th>Level</th>
<th>Percentage of Advanced GCE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>AO1</td>
</tr>
<tr>
<td>2526</td>
<td>AS</td>
<td>15</td>
</tr>
<tr>
<td>2527</td>
<td>AS</td>
<td>11</td>
</tr>
<tr>
<td>2528</td>
<td>AS</td>
<td></td>
</tr>
<tr>
<td>2529</td>
<td>A2</td>
<td>8</td>
</tr>
<tr>
<td>2530</td>
<td>A2</td>
<td>4</td>
</tr>
<tr>
<td>2531</td>
<td>A2</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>38</td>
</tr>
</tbody>
</table>

3.2 Quality of Written Communication

Credit is given for quality of written communication. Up to three marks in each written unit (2526, 2527, 2529 and 2530) are awarded for the clear and correct expression of ideas, use of technical terms and use of prose. The Projects (Units 2528 and 2531) also assess Quality of Written Communication.

Quality of Written Communication

In accordance with QCA requirements the quality of written communication demonstrated by a candidate is assessed where appropriate. Quality of written communication is awarded marks in accordance with the following scale:

3 The candidate expresses complex ideas extremely clearly and fluently. Sentences and paragraphs follow on from one another smoothly and logically. Arguments are consistently relevant and well structured. There will be few, if any, errors of grammar, punctuation and spelling.

2 The candidate expresses straightforward ideas clearly, if not always fluently. Sentences and paragraphs may not always be well connected. Arguments may sometimes stray from the point or be weakly presented. There may be some errors of grammar, punctuation and spelling, but not such as to suggest a weakness in these areas.

1 The candidate expresses simple ideas clearly, but may be imprecise and awkward in dealing with complex or subtle concepts. Arguments may be of doubtful relevance or obscurely presented. Errors in grammar, punctuation and spelling may be noticeable and intrusive, suggesting weaknesses in these areas.

0 The language has no rewardable features.
4 Scheme of Assessment

Candidates take three units, including a coursework unit, for Advanced Subsidiary GCE, followed by a further three units, including a coursework unit, at A2 if they are seeking an Advanced GCE award.

Units of Assessment

<table>
<thead>
<tr>
<th>Unit</th>
<th>Level</th>
<th>Name</th>
<th>Mode of Assessment</th>
<th>Duration</th>
<th>Weighting %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>AS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Advanced GCE</td>
</tr>
<tr>
<td>2526</td>
<td>AS</td>
<td>Foundations of Electronics</td>
<td>Written Examination</td>
<td>1 hour 30 mins</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20%</td>
</tr>
<tr>
<td>2527</td>
<td>AS</td>
<td>Signal Processing</td>
<td>Written Examination</td>
<td>1 hour 15 mins</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15%</td>
</tr>
<tr>
<td>2528</td>
<td>AS</td>
<td>Electronics Project 1</td>
<td>Coursework</td>
<td>-</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15%</td>
</tr>
<tr>
<td>2529</td>
<td>A2</td>
<td>Communication Circuits</td>
<td>Written Examination</td>
<td>1 hour 30 mins</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20%</td>
</tr>
<tr>
<td>2530</td>
<td>A2</td>
<td>Control Circuits</td>
<td>Written Examination</td>
<td>1 hour 15 mins</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15%</td>
</tr>
<tr>
<td>2531</td>
<td>A2</td>
<td>Electronics Project 2</td>
<td>Coursework</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15%</td>
</tr>
</tbody>
</table>

Rules of Combination

Candidates must take the following combination of units.

Advanced Subsidiary GCE Units 2526, 2527 and 2528.

Advanced GCE Units 2526, 2527, 2528, 2529, 2530 and 2531.

Unit Availability

There are two assessment sessions each year, in January and June. The availability of units is shown below.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Level</th>
<th>Unit Title</th>
<th>Jan 2001</th>
<th>June 2001</th>
<th>Jan 2002</th>
<th>June 2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>2526</td>
<td>AS</td>
<td>Foundations of Electronics</td>
<td>-</td>
<td>✓</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>2527</td>
<td>AS</td>
<td>Signal Processing</td>
<td>-</td>
<td>✓</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>2528</td>
<td>AS</td>
<td>Electronics Project 1</td>
<td>-</td>
<td>✓</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>2529</td>
<td>A2</td>
<td>Communication Circuits</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>2530</td>
<td>A2</td>
<td>Control Circuits</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>2531</td>
<td>A2</td>
<td>Electronics Project 2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
</tr>
</tbody>
</table>
In 2001, only the Advanced Subsidiary (AS) units shown in the table will be available. The availability shown for 2002 will be the same in subsequent years.

Sequence of Units

The normal sequence in which the units could be taken is Units 2526, 2527 and 2528 in the first year of a course of study, leading to an Advanced Subsidiary GCE award then Units 2529, 2530 and 2531 in the second year, together leading to the Advanced GCE award. However, the units may be taken in other sequences.

Alternatively, candidates may take all units at the end of their Advanced Subsidiary GCE or Advanced GCE course in a ‘linear’ fashion.

Synoptic Assessment

Synoptic assessment tests the candidates’ understanding of the connections between the different parts of the subject. It accounts for at least 20% of the total Advanced GCE marks. Units 2529 and 2530 contain synoptic questions accounting for 15% of the overall Advanced GCE marks. Unit 2531 contains some synoptic assessment, accounting for 5% of the overall Advanced GCE marks.

For Advanced GCE, Units 2529, 2530 and 2531 must be taken at the end of a candidate’s course of study.

Aggregation

Candidates may enter for:

- Advanced Subsidiary GCE aggregation;
- Advanced Subsidiary GCE aggregation, bank the result, and complete the A2 assessment at a later date;
- Advanced GCE aggregation.

Candidates must enter all six Advanced Subsidiary and A2 units to qualify for the full Advanced GCE award.

Individual unit results, prior to the certification of the qualification, have a shelf-life limited only by the shelf-life of the specification.

Re-sits of Units

Candidates are permitted to re-sit all units once only, before seeking an Advanced Subsidiary GCE or Advanced GCE award, and the better result will count.

Re-sits of Advanced Subsidiary GCE and Advanced GCE

Candidates may retake the whole qualification more than once.
4.1 Question Papers

Candidates are expected to complete calculations, showing all their working, to an appropriate number of significant figures, giving a correct unit where required. Guidance on the assessment of quality of written communication is given in Section 3.2.

The mathematical requirements, together with a listing of abbreviations and symbols with which candidates are expected to be familiar, are given in Appendices F and G. Electronic calculators may be used in all the written papers, in accordance with OCR’s current regulations.

4.1.1 Advanced Subsidiary

Unit 2526 - Foundations of Electronics (1 hour 30 minutes) (120 marks)
Unit 2527 - Signal Processing (1 hour 15 minutes) (90 marks)

The question papers for Units 2526 and 2527 have a common format. They contain a variable number of structured questions which are answered on the question paper. All questions are compulsory.

4.1.2 A2

Unit 2529 - Communication Circuits (1 hour 30 minutes) (120 marks)
Unit 2530 - Control Circuits (1 hour 15 minutes) (90 marks)

The question papers for Units 2529 and 2530 have the same format as those for Units 2526 and 2527. They contain a variable number of structured questions which are answered on the question paper. All questions are compulsory.

Marks on each of the papers for Units 2529 and 2530 examine the links between Units 2526 and 2527 (the Advanced Subsidiary units) and the content of the particular unit. These questions are either set separately or integrated within questions directly relevant to the content of the A2 module. See ‘Synoptic Assessment’ above.
4.2 Coursework

Unit 2528 – Electronics Project 1 (Advanced Subsidiary) (78 marks)
Unit 2531 – Electronics Project 2 (A2) (90 marks)

One project, occupying between 15 and 20 hours of laboratory time, is completed for each unit. The projects submitted for Unit 2528 and Unit 2531 must be clearly different.

The assessment criteria for Unit 2528 and Unit 2531 are given in Appendix D. This includes details of the procedures to be followed during marking and internal standardisation.

4.2.1 Assessment and Moderation

All coursework is marked by the teacher and internally standardised by the Centre. Marks are then submitted to OCR by a specified date, after which postal moderation takes place in accordance with OCR procedures. The purpose of moderation is to ensure that the standard for the award of marks in coursework is the same for each Centre, and that each teacher has applied the standards appropriately across the range of candidates within the Centre.

Coursework submissions should be clearly annotated by the Centre to support the marks awarded to the candidates.

The work submitted to the Moderator for moderation must show how the marks have been awarded in relation to the marking criteria.

4.2.2 Minimum Coursework Requirements

If a candidate submits no work for a coursework unit, then the candidate should be indicated as being absent from that unit on the Coursework Mark Sheets submitted to OCR. If a candidate completes any work at all for a coursework unit then the work should be assessed according to the criteria and marking instructions and the appropriate mark awarded, which may be 0 (zero).

4.2.3 Authentication

As with all coursework, the teacher must verify that the work submitted for assessment is the candidate’s own work. Sufficient work must be carried out under direct supervision to allow the teacher to authenticate the coursework marks with confidence.
4.3 Special Arrangements

For candidates who are unable to complete the full assessment or whose performance may be adversely affected through no fault of their own, teachers should consult the Inter-Board Regulations and Guidance Booklet for Special Arrangements and Special Consideration. In such cases advice should be sought from OCR as early as possible during the course.

4.4 Differentiation

In the question papers, differentiation is achieved by setting questions which are designed to assess candidates at their appropriate levels of ability and which are intended to allow all candidates to demonstrate what they know, understand and can do.

In coursework, differentiation is by task and by outcome. Candidates undertake assignments which enable them to display positive achievement.

4.5 Awarding of Grades

The Advanced Subsidiary has a weighting of 50% when used in an Advanced GCE award. An Advanced GCE award is based on the aggregation of the weighted Advanced Subsidiary (50%) and A2 (50%) marks.

Both Advanced Subsidiary GCE and Advanced GCE qualifications are awarded on the scale A - E or U (unclassified).

4.6 Grade Descriptions

The following grade descriptions indicate the level of attainment characteristic of the given grade at Advanced level. They give a general indication of the required learning outcomes at each specified grade. The descriptions should be interpreted in relation to the content outlined in the specification; they are not designed to define that content. The grade awarded will depend in practice upon the extent to which the candidate has met the assessment objectives overall. Shortcomings in some aspects of the examination may be balanced by better performances in others.
Grade A

Candidates recall and use knowledge of electronics from the whole specification with few significant omissions and show good understanding of the principles and concepts they use. They select appropriate information from which to construct arguments or techniques with which to solve problems. In the solution of some problems, candidates bring together fundamental principles from different content areas of the common specification and demonstrate a clear understanding of the relationships between these.

Candidates apply knowledge and physical principles contained within the specification in both familiar and unfamiliar contexts. In questions requiring numerical calculations, candidates demonstrate good understanding of the underlying relationships between physical quantities involved and carry out all elements of extended calculations correctly, in situations where little or no guidance is given.

In experimental activities, candidates identify a problem, independently formulate a clear and effective plan, using knowledge and understanding of electronics, and use a range of relevant techniques with care and skill. They make and record measurements which are sufficient and with a precision which is appropriate to the task. They interpret and explain their results with sound use of physical principles and evaluate critically the reliability of their methods.

Grade C

Candidates recall and use knowledge of electronics from most parts of the specification and demonstrate understanding of a significant number of the main principles and concepts within it. They select and make good use of information that is presented in familiar ways to solve problems, and make some use of the concepts and terminology of electronics in communicating their answers. In their answers to some questions, candidates demonstrate some knowledge of the links between different areas of electronics.

Candidates apply knowledge and physical principles contained within the specification when the context provides some guidance on the required area of work. They show some understanding of the physical principles involved and the magnitudes of common physical quantities when carrying out numerical work. Candidates carry out calculations in most areas of electronics correctly when these calculations are of a familiar kind or when some guidance is provided, using correct units for most physical quantities.

In experimental activities, candidates formulate a clear plan. They make and record measurements with skill and care and show some awareness of the need for appropriate precision. They interpret and explain their experimental results, making some use of fundamental principles of electronics and mathematical techniques.
Grade E

Candidates recall knowledge of electronics from parts of the specification and demonstrate some understanding of fundamental principles and concepts. Their level of knowledge and understanding may vary significantly across major areas of the specification. They select discrete items of knowledge in structured questions and make some use of the terminology of electronics in communicating answers.

Candidates apply knowledge and principles of electronics contained within the specification to material presented in a familiar or closely related context. They carry out straightforward calculations where guidance is given, usually using the correct units for physical quantities. They use some fundamental skills of electronics in contexts which bring together different areas of the subject.

In experimental activities, candidates formulate some aspects of a practical approach to a problem. They make and record some appropriate measurements, showing care and appropriate procedure in implementation. They present results appropriately and provide some descriptive interpretation of the outcomes of the investigation.
5 Specification Content

These specifications are set out in the form of teaching modules. Each teaching module is assessed by its associated unit of assessment.

5.1 Module 2526: Foundations of Electronics

N3.1, N3.2, N3.3.  PS3.1, PS3.2.

Recommended Prior Knowledge

Candidates should:

• understand the concepts of conductors and insulators in terms of the mobility of charge;
• understand voltage as a measure of the energy of charge at a point in a circuit;
• understand current as the rate of transfer of charge past a point in a circuit;
• know of the need for suitable power supplies to drive a current round a circuit;
• recognise the conversion of energy from electrical to other forms as charge moves round a circuit.

5.1.1 System Components

Content

The list of devices below defines a set of basic components with which candidates should be familiar. No detailed knowledge of the physics of each device is required. Where possible, devices will be treated as ideal in calculations. The limitations of devices should be understood. Devices may be treated as ‘black boxes’ with outputs defined in terms of their inputs.

• Resistors, combinations of resistors and the potential divider;
• Capacitors and their uses in storing charge;
• Diodes and diode-resistor networks. The Zener diode;
• Mains transformers, assumed to be ideal and loss-free;
• Input transducers: push switch, potentiometer, potential divider incorporating LDR or thermistor, audio microphone, series resistor and visible or IR photodiode;
• Output transducers: loudspeaker, lamp, visible and IR LEDs, relay, d.c. motor, heater;
• Measuring instruments: voltmeter, ammeter and ohmmeter, CRO.
Learning Outcomes

Candidates should be able to:

(a) define resistance \( R = \frac{V}{I} \) and the ohm;
(b) distinguish between ohmic and non-ohmic devices; characteristics of LDRs and ntc thermistors;
(c) recall and use formulae to calculate the total resistance of resistors in series and parallel;
(d) recall the definition of capacitance \( C = \frac{Q}{V} \) and the farad;
(e) use capacitors to store charge;
(f) use diodes regarded as one-way conductors with a constant voltage drop in the forward direction once biased, and zero leakage current in the reverse direction;
(g) recall that the voltage across a forward biased diode is 0.7 V for a silicon diode, 0 V for a germanium diode and 2.0 V for an LED; the breakdown voltage of a Zener diode is constant;
(h) design simple circuits using diodes as rectifiers and clamps (including protection diodes in relay circuits);
(i) select and incorporate in circuits suitable input and output transducers (regarded as named sub-system ‘black boxes’) from the list in the content part of this section;
(j) select and use appropriate measuring instruments;
(k) incorporate the system components listed above as sub-systems in simple electronics systems.

5.1.2 Fundamentals of Circuit Building

Content

All circuits may be regarded as systems which in turn may be considered as a set of mutually interacting sub-systems. A system which is to perform a particular task may be synthesised in many different ways.

- Simple analysis of practical circuits;
- RC networks;
- Power and energy transfer in circuits;
- Power supplies.
Learning Outcomes

Candidates should be able to:

(a) use the concepts of voltage as a means of driving a current through a conductor, and current as a rate of transfer of charge;

(b) recall and use the defining equations for resistance and capacitance \( R = \frac{V}{I} \) and \( C = \frac{Q}{V} \);

(c) recall and use the rules for the behaviour of currents at junctions (Kirchhoff’s first law) and how voltage changes from one part of a circuit to another \( (V = IR) \);

(d) recall and use RC networks to generate time delays and pulses; use appropriate formulae to calculate the voltage across components as a function of time when a capacitor is charged or discharged through a resistor from a constant voltage source;

(e) recall that current flow in a circuit implies energy transfer; recall and use the equations to calculate energy and power dissipation in d.c. circuits: \( Q = It \), energy = \( VQ \), \( P = VI = I^2R \);

(f) recall the relationship between peak and r.m.s. values for sinusoidal a.c.;

(g) explain the operation of power supply circuits containing mains transformers, diodes and a capacitor to produce a smoothed, unstabilised d.c. supply, to include calculation of peak voltage and ripple voltage;

(h) design simple power supply circuits using both full-wave and half-wave rectification and stabilised by a Zener diode or by a voltage regulator chip;

(i) design and construct simple systems;*

(j) find and correct faults in simple systems.*

* These outcomes will not be assessed in Unit 2526 examinations.

5.1.3 Operational Amplifier Systems

Content

Although candidates should be aware of the non-ideality of a commercial operational amplifier, most of the following systems may be treated as ideal with infinite open-loop gain and infinite input impedance. Systems should be considered as ‘black boxes’ with outputs defined as a function of the input.

- Comparator and switch;
- Negative feedback;
- Inverting and non-inverting amplifiers;
- Voltage follower.
Learning Outcomes

Candidates should be able to:

(a) recall and use the op-amp as a switch with voltage controlled differential inputs;
(b) use the concept of the potential divider to allow input transducers to activate the op-amp switch;
(c) use the concept of negative feedback to stabilise the output of an op-amp and to define its closed-loop gain when not saturated, in terms of the external components in the feedback loop;
(d) recall and use the concept of a virtual earth for an inverting amplifier;
(e) derive and use the appropriate formulae for the closed loop gain of both inverting and non-inverting amplifiers when not saturated;
(f) understand the use of a voltage follower as a buffer amplifier.

5.1.4 Digital Systems

Content

- AND, OR, NOT, NAND, NOR and EOR gates;
- Combinational logic systems and truth tables involving up to 16 states;
- Binary arithmetic, the use of half adders and full adders;
- Bistables and latches;
- The D-type flip-flop;
- Sequential logic analysed from timing diagrams.

Learning Outcomes

Candidates should be able to:

(a) recall that, unless otherwise stated, logic 1 = +5 V, logic 0 = 0 V and use truth tables and transfer characteristics of NOR, NAND, NOT, AND, OR and EOR gates;
(b) synthesise each of these gates from dual-input NAND gates or dual-input NOR gates;
(c) explain the operation of simple combinational logic systems such as binary-to-decimal and binary-to-seven-segment decoders; half and full adders, using truth tables;
(d) recall and describe the operation of bistable (latch) circuits made from two cross-coupled NAND gates or two cross-coupled NOR gates;
(e) recall and describe the operation of a rising edge triggered D-type flip-flop;
(f) interpret simple sequential logic circuits in terms of timing diagrams.
5.2 Module 2527: Signal Processing

Recommended Prior Knowledge
Candidates should have studied Module 2526.

5.2.1 Negative Feedback

Content

- Operational amplifiers and their characteristics;
- The summing amplifier;
- Active filters.

Learning Outcomes
Candidates should be able to:

(a) recall and interpret the characteristics of an 081 (741 compatible) op-amp neglecting offset adjustments;

(b) recall and use the concept of negative feedback to stabilise the output of an amplifier circuit and to define its output state solely in terms of its input and the values of external components;

(c) design and use summing amplifier circuits to add or mix multiple inputs;

(d) explain the use of the capacitor as a frequency-dependent impedance;

(e) design and use simple filter circuits constructed around an inverting amplifier circuit; suitable filters would include bass and treble cut, bass and treble boost, and bandpass filters;

(f) recall and use the formula to calculate the break frequency of a filter;

(g) draw log-log plots of the gain of the filter circuit as a function of frequency, using the straight line approximation.
5.2.2 Positive Feedback

Content

- Schmitt trigger circuits;
- Ramp generator (integrator) circuits;
- The signal generator.

Learning Outcomes

Candidates should be able to:

(a) recall and use the concept of positive feedback to convert an amplifier into a device with only two stable states;
(b) design and use both inverting and non-inverting Schmitt trigger circuits using op-amps;
(c) calculate the trigger thresholds for both inverting and non-inverting types and also create asymmetrical threshold levels;
(d) design and use an op-amp as a ramp generator or integrator;
(e) combine a ramp generator and a Schmitt trigger to make a ramp/square wave generator;
(f) calculate the frequency of the ramp/square wave generator.

5.2.3 Boolean Algebra and Synchronous Counters

Content

- The rules for AND and OR operations;
- De Morgan’s theorem, the redundancy theorem and the race hazard theorem;
- The use of Boolean algebra to simplify combinational logic systems;
- Counters.

Learning Outcomes

Candidates should be able to:

(a) generate simple Boolean algebra expressions and truth tables from a problem specification;
(b) use De Morgan’s theorem to simplify algebraic expressions to a form suitable for implementation in terms of basic logic gates (no knowledge of Karnaugh Maps is expected);
(c) convert a circuit formed of one sort of gate into its equivalent in the other sort;
(d) recognise the use of the redundancy theorem and the race hazard theorem,
(e) construct truth tables for a combinational logic circuit and generate corresponding Boolean expressions;
(f) construct and use timing diagrams to explain the operation of sequential logic circuits;
(g) recall and describe the operation of a binary ripple up-counter made from D-type flip-flops;
(h) design and construct binary counters which reset after n counts.

5.2.4 Analysis of Systems

Content

- Systems defined by their transfer characteristics, input and output impedance, the ability to source and sink current;
- Analysis of systems in terms of block diagrams;
- The audio amplifier;
- Digital systems.

Learning Outcomes

Candidates should be able to:
(a) interpret the performance of a system from its transfer characteristic;
(b) recall and use the concepts of input impedance and output impedance to solve problems of power and signal transfer between systems and sub-systems;
(c) recall that outputs can act as both sources and sinks of current;
(d) explain the operation of a complete audio amplifier system in terms of blocks representing pre-amplifier, equaliser, volume and tone controls, and power amplifier;
(e) design and explain the operation of simple systems, such as quiz referee, combination lock and simple decimal keypad, made up from components and sub-systems;
(f) apply skills learned in this module to design and explain the operation of related systems.
5.3 Module 2528: Electronics Project 1

This is a coursework module which is assessed via Unit 2528.

Candidates are required to design and assemble an electronic system which is potentially useful to a technology-based society. Candidates are expected to go through at least one cycle of design, construction, evaluation and modification.

Some ideas for suitable projects for Module 2528 are given in Appendix C. Project Assessment Criteria are given in Appendix D.
5.4 Module 2529: Communication Circuits

Recommended Prior Knowledge
Candidates should have studied Modules 2526 and 2527.

5.4.1 Resonant Circuits

Content
- Inductors and capacitors;
- The parallel resonant circuit.

Learning Outcomes
Candidates should be able to:
(a) describe the effects of incorporating ideal inductors (i.e. neglecting resistance and self-capacitance) and ideal capacitors (i.e. neglecting leakage resistance and self-inductance) in circuits;
(b) recall and use the parallel resonant circuit as a frequency dependent impedance with a maximum impedance at $f = 1/(2\pi\sqrt{LC})$;
(c) recall that $Q$ describes the sharpness of the resonance and is determined by the resistance in the circuit;
(d) appreciate the effect of $Q$ in designing circuits for selecting a small range of frequencies out of the frequency spectrum.

5.4.2 Transistor Circuits

Content
- NPN and PNP transistors;
- Transistor voltage amplifiers;
- The complementary emitter follower;
- The $n$-channel MOSFET as a high impedance amplifier;
- The $n$-channel MOSFET as a voltage controlled resistor.
Learning Outcomes

Candidates should be able to:

(a) recall and interpret the transfer characteristics of both NPN and PNP transistors;
(b) recall that for a transistor, the dc current gain $h_{FE}$ is assumed to be constant, $V_{BE}$ is taken as 0.7 V and $V_{CE}$ (saturation) is taken as zero for a conducting transistor;
(c) recall and design NPN transistor voltage amplifier circuits using single resistor base bias circuits full dc stabilisation;
(d) recall the use of blocking capacitors on inputs and outputs of amplifiers;
(e) calculate the voltage gain of a fully stabilised transistor amplifier;
(f) recall the use of a transistor as a buffer, emitter follower or power amplifier with unity voltage gain; recall that the power gain is the ratio power out/power in;
(g) recall the use of a PNP-NPN pair of transistors as a complementary emitter follower to drive a current in both directions from a dual supply, through a load;
(h) recall the causes of, and methods of correction (using op-amps) for, cross-over distortion and clipping in complementary emitter followers;
(i) recall the characteristics of a n-channel MOSFET;
(j) recall the use of the n-channel MOSFET in high impedance amplifier and voltage follower circuits;
(k) recall the use of the n-channel MOSFET as a voltage controlled resistor in automatic gain control circuits and amplitude modulation circuits and as an analogue switch.

5.4.3 Analogue Communication Systems

Content

• Signal transfer on carrier waves;
• Amplitude Modulation (AM) and frequency modulation (FM) of carrier waves;
• Frequency division multiplexing of signals;
• AM and FM receivers.

Learning Outcomes

Candidates should be able to:

(a) recall and describe the transfer of signals by various carriers (for example, radio, light and ultrasound);
(b) describe and explain the use of AM and FM carriers to transfer analogue signals;
(c) explain the effects of noise and information loss in carriers.
(d) recall the frequency spectrum of AM carriers modulated by sine wave and square wave signals;
(e) recall the bandwidth required to transmit FM signals is greater than for AM signals;
(f) recall and describe the use of frequency division multiplexing to allow the simultaneous transmission of several signals;
(g) describe and explain in detail the operation of a simple AM receiver using a parallel resonant circuit and a diode (assumed to be ideal) detector;
(h) recall and explain how the shortcomings of the simple AM receiver may be overcome in t.r.f. and superhet systems (candidates will only be asked to supply block diagrams);
(i) analyse the operation of a simple FM receiver, including why the signal-to-noise ratio can be much lower than in an AM system (no knowledge of phase-locked loops is expected).

5.4.4 Television Systems

Content

- Television receivers as convertors of serial analogue electronic signals into analogue pictures (candidates will not be expected to reproduce block or circuit diagrams for television systems).

Learning Outcomes

Candidates should be able to:

(a) recall the following terms as applied to the generation of pictures on a cathode ray tube: pixel, line, field, raster, interlacing, synchronisation signals, resolution, lines per field, fields per second, luminance and chrominance;
(b) describe, at a simple level, the encoding of colours and the intermodulation of sound;
(c) calculate the bandwidth required for a given picture.

5.4.5 Digital Communication Systems

Content

- Comparisons between analogue and digital information transfer
- Digital-to-analogue conversion (DAC) and analogue-to-digital conversion (ADC) based on DACs;
- The dependence of required bandwidth on bit rate for a digital system;
• Sub-systems of digital systems: shift registers, monostables, astables, Schmitt trigger circuits;
• Pulse code modulation and time division multiplexing;
• Asynchronous serial transmission.

Learning Outcomes

Candidates should be able to:

(a) recall the comparative merits and demerits of analogue and digital systems;
(b) use and explain the operation of the DAC using op-amps and resistor networks;
(c) use and explain the operation of a single slope ADC based on a DAC;
(d) recall the dependence of the required bandwidth on the bit rate for a digital system (for example, in telex systems and for picture transmission in television and other systems); minimum sampling rate greater than twice highest frequency;
(e) recall and explain the operation of shift registers in the parallel and serial processing of binary words;
(f) use shift registers as functional blocks or assembled from D-type flip-flops;
(g) design and use pairs of NAND or NOR gates and RC networks to construct a monostable, a Schmitt trigger, and an oscillator which can be enabled;
(h) recall and explain the use of pulse code modulation (p.c.m.);
(i) recall and describe the use of time division multiplexing to allow the simultaneous transmission of several signals on the same channel;
(j) analyse the operation of circuits for serial transmission and reception.
5.5 Module 2530: Control Circuits

Recommended Prior Knowledge
Candidates should have studied Modules 2526, 2527 and 2529.

5.5.1 d.c. Servo Control Systems

Content
- Control systems for position, temperature and rotational speed;
- On-off and proportional systems;
- The response of a system as a function of the characteristics of its sub-systems.

Learning Outcomes
Candidates should be able to:
(a) recall and explain the operation of simple d.c. servo systems to control position, temperature and rotational speed.
(b) distinguish between and design on-off and proportional systems for the above applications.

5.5.2 Triacs

Content
- Triacs used in simple control circuits;
- The triac to allow logic systems to control high voltage alternating currents.

Practical work must not include access to mains voltages.

Learning Outcomes
Candidates should be able to:
(a) recall circuitry to allow logic systems to interface with triacs to control high voltage circuits;
(b) recall and explain the use of opto-couplers and pulse transformers to isolate the one system from another (for example, a logic system from the high voltage side of a triac).
5.5.3 Logic and Memory Systems

Content

- Tristates to link two or more logic outputs to drive the same line;
- The construction of RAM from D-type flip-flops, tristates and logic gates;
- The use of RAM to read and write binary words from a common data bus;
- The use of registers in the storage and processing of binary words.

Learning outcomes

Candidates should be able to:

(a) recall and explain the use of tristates as devices which allow two or more logic systems to drive a common line;
(b) explain the construction and operation of RAM using D-type flip-flops, tristates and logic gates as sub-systems;
(c) recall and describe the use of RAM to read and write binary words from a common data bus;
(d) recall and describe the use of registers in the storage and processing of binary words;
(e) construct registers from D-type flip-flops.

5.5.4 Microprocessor Systems

Content

- Microprocessor systems treated as an assembly of sub-system blocks;
- The terminology of the operation of microprocessor systems;
- Using the microprocessor to carry out simple tasks by writing and analysing machine code software.

Learning Outcomes

Candidates should be able to:

(a) recall and describe the microprocessor as a programmable assembly of memory, tristates, latches, registers and logic gates;
(b) explain the operation of a simple microprocessor in terms of a block diagram, including blocks for the clock, CPU, RAM, ROM, input and output ports;
(c) explain the use of the following terms in the context of microprocessor systems: bit, byte, word length, clock, accumulator, arithmetic and logic unit, instruction register, general
purpose register, program counter, fetch-execute cycle, program jumps and branching, sub-
routines, look-up table, direct and indirect addressing, RAM and ROM, 8-bit input and output
ports, data bus, address bus, control bus, flow chart, hexadecimal code, interrupt,
handshaking, central processing unit, memory, memory pointer;

(d) recall and explain the use of interrupts to allow an external device to be serviced on request;

(e) describe the use of the stack to store the contents of the program counter and other
registers before the interrupt routine is started, and the restoration of the contents of the
registers at the end of the interrupt routine;

(f) write and analyse software in machine code using the instruction set for an imaginary 8-bit
microprocessor system in Appendix E;

(g) write and analyse software to accomplish the following tasks:

(i) the control of up to 8 parallel output lines, including the generation of sequences of
binary words with time delays between change;

(ii) driving a 7-segment LED display from a look-up table;

(iii) multiplexing several 7-segment LED displays from eight lines;

(iv) the switching of devices via relays and triacs;

(v) the rotational control of a stepper motor, including causing single steps in either
direction, a fixed number of steps and steps at a specified rate to produce a specified
angular velocity;

(vi) the use of a digital-to-analogue converter to produce square, triangular and saw-tooth
waveforms; no understanding of the construction of the DAC is required;

(vii) the use of switches to input data to a microprocessor system: the need for a hand-
shaking flip-flop to synchronise the input device and the microprocessor;

(viii) sampling, storing and displaying an analogue signal with the aid of an analogue-to-
digital converter; no understanding of the construction of the ADC is required;

(ix) control of external systems, using sensors connected to the input port and actuators
connected to the output port.
5.6 Module 2531: Electronics Project 2

This is a coursework module which is assessed by Unit 2531.

Candidates are required to design and assemble an electronic system which is potentially useful to a technology-based society. Candidates are expected to go through at least one cycle of design, construction, evaluation and modification.

Some ideas of suitable projects for Module 2531 are given in Appendix C. Project Assessment Criteria are given in Appendix D.
6 Further Information and Training for Teachers

To support teachers using these specifications, OCR will make the following materials and services available:

- up-to-date copies of these specifications;
- a full programme of In-Service Training (INSET) meetings;
- specimen question papers and mark schemes;
- past question papers and mark schemes after each examination session;
- coursework guidance materials;
- written advice on coursework proposals;
- individual feedback to each Centre on the moderation of coursework;
- a Report on the Examination, compiled by senior examining personnel, after each examination session.

If you would like further information about these specifications, please contact OCR.
The following books may be useful.

**For Candidates**


**For Teachers**

Appendix A

Key Skills

This Appendix offers detailed guidance on the Key Skills evidence that a candidate might produce during their programme of study. It focuses on the evidence required to meet the criteria for the internally assessed Key Skills portfolio. For example, in producing work for assessment as evidence of C3.2 (Read and synthesise information from two extended documents about a complex subject. One of these documents should include at least one image.) a candidate is required to:

- select and read material that contains the information you need;
- identify accurately, and compare, the lines of reasoning and main points from text and images; and
- synthesise the key information in a form that is relevant to your purpose.

The Key Skills and Evidence Requirements below are quoted from Part B of the QCA Key Skills specifications and, as such, are addressed to the candidate. The text below the Evidence Requirements is guidance for teachers about how the specifications might be used to provide teaching and learning opportunities and/or assessment opportunities for the Key Skill.

For further information, teachers should refer to QCA’s Key Skills specifications for use in programmes starting from September 2000.

For further information about the assessment and certification of Key Skills, teachers should contact OCR.

C3  Communication Level 3

C3.1a  Contribute to a group discussion about a complex subject.

Evidence requirements
(i) Make clear and relevant contributions in a way that suits your purpose and situation.
(ii) Listen and respond sensitively to others, and develop points and ideas.
(iii) Create opportunities for others to contribute when appropriate.

Possible opportunities
Group work requires consultation between candidates.
Module 2527

Candidates could work in groups to design a system (see section 5.2.4(f)).

C3.1b

Make a presentation about a complex subject, using at least one image to illustrate complex points.

Evidence requirements

(i) Speak clearly and adapt your style of presentation to suit your purpose, subject, audience and situation.

(ii) Structure what you say so that the sequence of information and ideas may be easily followed.

(iii) Use a range of techniques to engage the audience, including effective use of images.

Possible opportunities

A candidate could make a presentation about a project carried out either individually or in a group.

Module 2527

Candidates could make a presentation about a system they had helped to design (see C3.1a above).

Module 2528 and Module 2531

Candidates could make a presentation about their project.

C3.2

Read and synthesise information from two extended documents that deal with a complex subject. One of these documents should include at least one image.

Evidence requirements

(i) Select and read material that contains the information you need.

(ii) Identify accurately, and compare, the lines of reasoning and main points from texts and images.

(iii) Synthesise the key information in a form that is relevant to your purpose.

Possible opportunities

In the coursework modules, project reports are produced.
C3.3 Write two different types of documents about complex subjects. One piece of writing should be an extended document and include at least one image.

Evidence requirements
(i) Select and use a form and style of writing that is appropriate to your purpose and complex subject matter.
(ii) Organise relevant information clearly and coherently, using specialist vocabulary when appropriate.
(iii) Ensure your text is legible and your spelling, grammar and punctuation are accurate so your meaning is clear.

Possible opportunities
The assessment criteria for the projects allow the opportunity for C3.3 to be assessed.

Module 2528 and Module 2531
The project assessment criteria include clarity of style, appropriate choice of layout and headings and use of IT. An evaluation is also required.

N3 Application of Number Level 3

You must:
Plan and carry through at least one substantial and complex activity that includes tasks for N3.1, N3.2 and N3.3.
N3.1 Plan, and interpret information from two different types of sources, including a large data set.

Evidence requirements
(i) Plan how to obtain and use the information required to meet the purpose of your activity.
(ii) Obtain the relevant information.
(iii) Choose appropriate methods for obtaining the results you need and justify your choice.

Possible opportunities
There are many opportunities to plan and interpret information from different sources.

All Modules
Candidates have to collect information for combinations of electronic components.

N3.2 Carry out multi-stage calculations to do with:

(a) amounts and sizes;
(b) scales and proportion;
(c) handling statistics;
(d) rearranging and using formulae.

You should work with a large data set on at least one occasion.

Evidence requirements
(i) Carry out calculations to appropriate levels of accuracy, clearly showing your methods.
(ii) Check methods and results to help ensure errors are found and corrected.

Possible opportunities
There are many opportunities to carry out multi-stage calculations.

All Modules
Multi-stage calculations have to be carried out in Electronics to enable circuits to be designed and their behaviour to be analysed.
**N3.3** Interpret results of your calculations, present your findings and justify your methods. You must use at least one graph, one chart and one diagram.

**Evidence requirements**

(i) Select appropriate methods of presentation and justify your choice.

(ii) Present your findings effectively.

(iii) Explain how the results of your calculations relate to the purpose of your activity.

**Possible opportunities**

There are many opportunities to interpret results of calculations.

*Module 2526*

Candidates describe quantitatively the use of capacitors in storing charge (see section 5.1.1).

Candidates design power supplies (see section 5.1.2).

*Module 2527*

Candidates design and use operational amplifier circuits (see section 5.2.1).

*Module 2529*

Candidates combine inductors and capacitors (see section 5.4.1).

*Module 2530*

Candidates use control systems (see section 5.5.1).

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**IT3 IT Level 3**

**You must:**

Plan and carry through at least one substantial activity that includes tasks for IT3.1, IT3.2, IT3.3.
IT 3.1  Plan, and use different sources to search for, and select, information required for two different purposes.

Evidence requirements

(i)  Plan how to obtain and use the information required to meet the purpose of your activity.

(ii) Choose appropriate sources and techniques for finding information and carry out effective searches.

(iii) Make selections based on judgements of relevance and quality.

Possible opportunities

The coursework projects offer an opportunity to use IT.

Module 2528 and Module 2531

The project assessment criteria include investigation into alternative solutions via IT.

IT 3.2  Explore, develop, and exchange information and derive new information to meet two different purposes.

Evidence requirements

(i)  Enter and bring together information in a consistent form, using automated routines where appropriate.

(ii) Create and use appropriate structures and procedures to explore and develop information and derive new information.

(iii) Use effective methods of exchanging information to support your purpose.

Possible opportunities

The coursework projects offer an opportunity to use IT.

Module 2528 and Module 2531

The project assessment criteria include elegance, brilliance and originality of system and this may offer an opportunity for IT to be used.
IT3.3 Present information from different sources for two different purposes and audiences. Your work must include at least one example of text, one example of images and one example of numbers.

Evidence

(i) Develop the structure and content of your presentation using the views of others, where appropriate, to guide refinements.

(ii) Present information effectively, using a format and style that suits your purpose and audience.

(iii) Ensure your work is accurate and makes sense.

Possible opportunities

The coursework projects offer an opportunity to use IT.

Module 2528 and Module 2531

The project assessment criteria includes clarity of style, appropriate choice of layout and headings and use of IT.

WO3 Working with Others Level 3

You must:

Provide at least one substantial example of meeting the standard for WO3.1, WO3.2 and WO3.3 (you must show that you can work in both one-to-one and group situations).

WO3.1 Plan complex work with others, agreeing objectives, responsibilities and working arrangements.

Evidence requirements

(i) Agree realistic objectives for working together and what needs to be done to achieve them.

(ii) Exchange information, based on appropriate evidence, to help agree responsibilities.

(iii) Agree suitable working arrangements with those involved.
Possible opportunities

There may be opportunities in the coursework projects and in group activities organised in other modules.

*Module 2527*

Candidates working together in groups (see C3.1a above) could meet the evidence requirements of WO3.1.

*Module 2528 and Module 2531*

Candidates have to discuss with their teachers the choice of projects.

There may be further opportunities to plan complex work with others if their choice of project requires. Suitable equipment may need to be shared and so suitable working arrangements have to be arranged with those involved.

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**WO3.2**

Seek to establish and maintain co-operative working relationships over an extended period of time, agreeing changes to achieve agreed objectives.

**Evidence requirements**

(i) Organise and carry out tasks so you can be effective and efficient in meeting your responsibilities and produce the quality of work required.

(ii) Seek to establish and maintain co-operative working relationships, agreeing ways to overcome any difficulties.

(iii) Exchange accurate information on progress of work, agreeing changes where necessary to achieve objectives.

Possible opportunities

There may be opportunities in the coursework projects and in group work.

*Module 2527*

Candidates working together in groups (see C3.1a above) could meet the evidence requirements of WO3.1.

*Module 2528 and Module 2531*

Candidates have to discuss with their teachers the choice of projects.

There may be further opportunities to establish and maintain co-operative working relationships with others if their choice of project requires. Suitable equipment may need to be shared and so suitable working arrangements have to be arranged with those involved.
WO3.3 Review work with others and agree ways of improving collaborative work in the future.

Evidence requirements

(i) Agree the extent to which work with others has been successful and the objectives have been met.
(ii) Identify factors that have influenced the outcome.
(iii) Agree ways of improving work with others in the future.

Possible opportunities

There may be opportunities in the coursework projects and in group work.

Module 2527

Candidates working together in groups (see C3.1a above) could meet the evidence requirements of WO3.1.

Module 2528 and Module 2531

Candidates have to discuss with their teachers the choice of projects.

There may be further opportunities to review work with others if their choice of project requires. Suitable equipment may need to be shared and so suitable working arrangements have to be arranged with those involved and ways of improving collaborative work in the future.

LP3 Improving own Learning and Performance Level 3

You must:

Provide at least one substantial example of meeting the standard for LP3.1, LP3.2 and LP3.3.

LP3.1 Agree targets and plan how these will be met over an extended period of time, using support from appropriate people.

Evidence requirements

(i) Seek information on ways to achieve what you want to do, and identify factors that might affect your plans.
(ii) Use this information to agree realistic targets with appropriate people.
(iii) Plan how you will effectively manage your time and use of support to meet targets, including alternative action for overcoming possible difficulties.

Possible opportunities

There is an opportunity to agree targets and plan how they will be met in the coursework projects.

*Module 2528 and Module 2531*

Candidates are encouraged to discuss with their teachers the project to discover the feasibility of completing the task in the time available and with the equipment to hand.

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**LP3.2**

Take responsibility for your learning by using your plan, and seeking feedback and support from relevant sources, to help meet targets.

Improve your performance by:

- studying a complex subject;
- learning through a complex practical activity;
- further study or practical activity that involves independent learning.

**Evidence requirements**

(i) Manage your time effectively to complete tasks, revising your plan as necessary.

(ii) Seek and actively use feedback and support from relevant sources to help you meet your targets.

(iii) Select and use different ways of learning to improve your performance, adapting approaches to meet new demands.

**Possible opportunities**

There are many opportunities within the coursework projects to use your plan and seek feedback.

*Module 2528 and Module 2531*

The project assessment criteria include an investigation into alternative solutions via literature, IT or preliminary circuit assembly. There is also an opportunity to look at the economy of sub-systems and appropriate use of the available apparatus.

The elegance, brilliance, originality of system and perseverance is one of the project assessment criteria in A2 (Unit 2531).
LP3.3 Review progress on two occasions and establish evidence of achievements, including how you have used learning from other tasks to meet new demands.

Evidence requirements
(i) Provide information on the quality of your learning and performance, including factors that have affected the outcome.
(ii) Identify targets you have met, seeking information from relevant sources to establish evidence of your achievements.
(iii) Exchange views with appropriate people to agree ways to further improve your performance.

Possible opportunities
There are many opportunities within the coursework projects to use your plan and seek feedback.

Module 2528 and Module 2531
Candidates may have the opportunity through their projects to review their progress using the project assessment criteria and evaluation of the final system and in acknowledging all sources of assistance.
During the projects candidates are encouraged to discuss their progress with their teachers.

PS3 Problem Solving Level 3

You must:
Provide at least one substantial example of meeting the standard for PS3.1, PS3.2 and PS3.3.

PS3.1 Explore a complex problem, come up with three options for solving it and justify the option selected for taking forward.

Evidence requirements
(i) Explore the problem, accurately analysing its features, and agree with others on how to show success in solving it.
(ii) Select and use a variety of methods to come up with different ways of tackling the problem.
(iii) Compare the main features of each possible option, including risk factors, and justify the option you select to take forward.

Possible opportunities

There are many opportunities within Electronics where complex problems appear.

**Module 2526**

Candidates have to calculate values for combinations of resistors (see section 5.1.1).

Candidates have to calculate values for capacitors when used for storing charge (see section 5.1.1).

Candidates have to analyse practical circuits (see section 5.1.2).

**Module 2527**

Candidates have to use operational amplifier circuits (see section 5.2.1).

Candidates have to use Boolean algebra to simplify combinational logic systems (see section 5.2.3).

**Module 2529**

Candidates have to describe the effects of incorporating ideal inductors and ideal capacitors into circuits (see section 5.4.1).

Candidates have to analyse the operation of circuits for serial transmission and reception (see section 5.4.2).

**Module 2530**

Candidates have to analyse and construct programmes in machine code (see section 5.5.4).

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**PS3.2** Plan and implement at least one option for solving the problem, review progress and revise your approach as necessary.

**Evidence requirements**

(i) Plan how to carry out your chosen option and obtain agreement to go ahead from an appropriate person.

(ii) Implement your plan, effectively using support and feedback from others.

(iii) Review progress towards solving the problem and revise your approach as necessary.

Possible opportunities

There are many opportunities within Electronics where planning and implementing appear.

**Module 2526**

Candidates have to calculate values for combinations of resistors (see section 5.1.1).
Candidates have to calculate values for capacitors when used for storing charge (see section 5.1.1).

Candidates have to analyse practical circuits (see section 5.1.2).

**Module 2527**

Candidates have to use operational amplifier circuits (see section 5.2.1).

Candidates have to use Boolean algebra to simplify combinational logic systems (see section 5.2.3).

**Module 2528 and Module 2531**

The coursework projects give opportunities to plan how to carry out a chosen option and may give opportunities to review progress and revise the approach as necessary.

**Module 2529**

Candidates have to describe the effects of incorporating ideal inductors and ideal capacitors into circuits (see section 5.4.1).

Candidates have to analyse the operation of circuits for serial transmission and reception (see section 5.4.2).

**Module 2530**

Candidates have to analyse and construct programmes in machine code (see section 5.5.4).

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**PS3.3** Apply agreed methods to check if the problem has been solved, describe the results and review your approach to problem solving

**Evidence requirements**

(i) Agree, with an appropriate person, methods to check if the problem has been solved.

(ii) Apply these methods accurately, draw conclusions and fully describe the results.

(iii) Review your approach to problem solving, including whether alternative methods and options might have proved more effective.

**Possible opportunities**

There are many opportunities within Electronics where agreed methods can be used and the approach to problem solving can be reviewed.

**Module 2528 and Module 2531**

The project assessment criteria show opportunities for investigating alternative solutions, investigating sub-systems and checking whether the final solution fits the specification. The economy of sub-systems is also investigated and the reliability of operation of the final system.

An evaluation of the performance of the final system is also included.
Appendix B

Notes for Guidance on Coursework Assessment and Submission

Introduction

It is intended that each project will take between 15 and 20 hours of laboratory time. The project may be done in parallel with the theory units. Construction must be carried out in the Centre, and completed by the given date. Projects are assessed by the teacher and the assessment moderated by OCR.

Project titles need not be submitted to OCR before candidates begin work on them. However, OCR will offer advice on the suitability of proposed topics. Requests for advice should be made as early as possible. It is expected that projects for Unit 2528 (Advanced Subsidiary) will be based on material contained in Modules 2526 and 2527, to reflect the level of demand of the Advanced Subsidiary. Likewise, it is expected that projects in A2 (Unit 2531) will be based on more demanding material, drawing on the concepts in Modules 2529 and 2530.

Advanced GCE candidates should note that their two projects for Units 2528 and 2531 should be different. A second project which is a direct development of the first is unacceptable, and ideally the topics should be drawn from separate sections of the specification. (It is recognised that some topics chosen will lie outside the specification. This is acceptable.)

To ensure that the second project addresses different problems, the Unit 2528 project should be resubmitted at the same time as the Unit 2531. (This is for comparison only; the earlier project will not be reassessed.) It is the responsibility of the Centre to retain the Unit 2528 project reports, or photocopies of them, to cover this eventuality.

Choice of Project

Candidates must design a system to perform some useful function which must have an application relevant to a technologically-based society. Within this limitation, the candidate has a free choice of project. The Notes for Candidates (Appendix C) give further guidance on choice. The system must be specified at the outset so that the candidate can demonstrate a design-construct-evaluation-modification cycle during the progress of the project. The emphasis is on the electronic principles involved and not on the ‘quality’ of finish. (There is no requirement to produce a soldered circuit in a box; a project which is assembled on breadboard is sufficient.) Clearly, the teacher must discourage candidates from embarking on either over-ambitious or under-ambitious projects which might cause a failure to gain marks when assessed according to the Assessment Criteria (see Appendix D). Teachers should monitor the management of projects to ensure that candidates use their time effectively.
It is strongly recommended that projects which operate directly from the mains be avoided if at all possible. If a project has to involve direct connection to the mains, then the Centre must assume full responsibility for all aspects of its safety. (Contact should be made with the local Health and Safety Executive for guidance, if required.)

Assistance

Teachers must be careful not to give more assistance than is strictly necessary for the candidate to continue making progress. Part of the project assessment is concerned with how candidates react to circuits which do not work and how they persevere in the face of difficulties. On the other hand, candidates must feel that they may use the teacher as a resource, to be used as they might use a book from the library. Candidates are required to acknowledge all sources of assistance in their report.

Assessment

The teacher assesses the candidate’s project under three headings. They are analysis, solution and report (see Appendix D). The assessment sheet contains a number of statements under each heading, with a choice of marks which may be awarded to the candidate for the attributes mentioned in the statement.

Moderation Sample

It is the responsibility of the Centre to carry out internal standardisation where two or more teachers have been responsible for the assessment of projects. A single reliable order of merit must be produced.

Projects should not be dismantled until they have been photographed and the internal assessment process (and if necessary, the internal standardisation process) has been completed.

Following internal standardisation, marks are submitted to OCR by a specified date, after which postal moderation takes place in accordance with OCR procedures.

Hardware should not be sent to the moderator. The Moderator needs the report, together with a photograph of the completed project. Also required are teacher comments to support the assessment and to explain any deficiencies in the report. The report should be annotated by the teacher at the relevant point in the report. Alternatively, clear cross-references should be given in the report to a separate sheet of comments.

A project which generates no report may gain some marks for Analysis and Solution. In such a case, the teacher must include a full account of the circumstances with the moderation sample.
Notes for Candidates on Projects

Choice of Project

It is very likely that your Centre will have a list of possible projects from which you can choose. Further lists are printed below. This should not prevent you from making a proposal of your own. For each of Units 2528 and 2531 you are required to design and assemble an electronic system which is potentially useful to a technologically-based society. Having specified what your system is to do, it is expected that you will go through at least one cycle of design, construction, evaluation and modification.

Choose a topic which you find interesting and not above your general level of understanding of electronics. Bear in mind that a completed lower level project may be preferable to an incomplete high level one. The scope and style of the project will depend on the components and test equipment available in your Centre. Consult your teacher about your plans before you start work. You may expect to spend between 15 and 20 hours of laboratory time on each project. Projects which operate directly from the mains should be avoided if at all possible. If a project has to involve direct connection to the mains, then the Centre must assume full responsibility for all aspects of its safety. (The local Health and Safety Executive may be contacted for guidance, if required.) It is expected that the circuit will be constructed using breadboard, or equivalent: it is not necessary to transfer the circuit to a printed circuit board, or to mount the work in a suitable box.

Keep a record of the time you spend working on the various aspects of your project.

Project Report

A written report, meeting the requirements listed below as a minimum, must be submitted for assessment. In addition, any circuitry constructed will be inspected on a date to be notified by the Internal Assessor (teacher) and where appropriate the electronic functioning of such circuits must be demonstrated. Questions may be asked verbally about specific parts of the project and this interview will form a part of the total assessment.

The report must include:

- a summary of the work, not exceeding 200 words, of the aim of the project and how far that aim was achieved;
- a record of all the circuits tried, both successful and unsuccessful, with explanations of how the circuits worked or why they did not work;
- an evaluation of your final system. This should include an evaluation of its suitability for its stated purpose and any social and economic implications of the system;
- acknowledgement of all sources of assistance including references to books and other printed materials.
Assessment will be made on the quality of your work and not on the amount of time you have spent on it. You are strongly advised to refer to the Project Assessment Criteria (see Appendix D). High quality work will show evidence of each of the following:

- wide understanding of electronic principles;
- ability to devise a practical, operating electronic system meeting stated requirements;
- ability to evaluate the performance of an electronic system;
- ability to produce a satisfactory report of work done.

Your report may be word processed or hand-written. Although it should be neatly presented and easy to read, there is no need to use desktop publishing or other presentational techniques. It is better to spend time improving the content of the report.

A photograph of the completed project is required. You may wish to make this an integral part of your report.

The report should be submitted on A4 size paper. The separate sheets should be numbered and then stapled together at the top left hand corner. Graphs or diagrams should be inserted at the appropriate place in the text. Your report should not exceed 2500 words. Do not include material which is a direct copy from a book or journal. If the information is relevant, it is sufficient to quote it by reference.
Unit 2528 (Advanced Subsidiary)

This list gives some ideas which may be suitable for Advanced Subsidiary level projects.

- Electronic die to generate random numbers in the range 1-6, 0-9, 0-99. This is a popular project, and many solutions have been offered.
- Car security system. Operated by door switch and cancelled by keypad. Activates siren and flashing lights, and immobilises engine. Again, many variations on specification and solution.
- Voice disguise, to conceal speaker’s identity without hindering communication.
- Musical instrument tuner, comparing actual frequency with built-in accurate standard of 444Hz.
- Fruit machine. An ever-present favourite.
- Telephone timer, to monitor and display call length while in progress, and to hold the display afterwards.
- Bar counter. This is a sophisticated metronome, displaying the number of the bar reached in the score. Useful for percussion players, for example.
- Doorbell for the deaf. A portable unit ‘hears’ the doorbell, and flashes a light. The light continues to flash until cancelled.
- Pace controller. A training aid for runners, sold commercially. This could use a pressure pad in the shoe, and compare actual performance with a pre-set standard.
- Infra-red people counter. This could be used to record customers entering a library.
- Stroke rate meter, suitable for any rowing boat. Measures the time for two strokes, converts to strokes per minute and displays the value.
- Pelican crossing lights. This one is a perennial favourite. There are many different solutions, and lots of scope for originality and development.
- Signal generator with range 20 Hz to 20 kHz. Sine wave, square or triangular outputs available.
- Metronome. Another popular project, with a variety of specifications and solutions.
- Fridge alarm. An audible warning of temperature rise above a pre-set value. Requires latching, and careful calibration over the range of pre-set temperature required.
- Chess clock.
- Programmable disco lights. Very popular, usually with low-voltage output.
- Pulse rate monitor. An essential training aid used by athletes, cyclists and others.
- Number-guessing game. A distant relative of the once-popular ‘Mastermind’.
- Control system for wine fermentation heater.
Unit 2531 (A2)

This list gives some ideas, based on more demanding topics, which may be suitable for Unit 2531 projects.

- Pedometer, adjustable for stride length. Displays total distance covered, up to 999 m.
- Speed control of d.c. motor. Desired speed is set by keypad.
- Spectrum analyser for stereo system.
- Quizmaster with infra-red controls.
- Radio remote control of professional VCR. System employs UART and microprocessor components. (Professional VCR is not normally remote-operated. Radio-transmission regulations must be observed).
- Delay and echo unit for electric guitar. Many variations have been offered.
- Ultrasonic tape measure. Achieving a range exceeding 1 metre often provides a real challenge.
- ‘Cricket Master’, for umpires. It counts balls bowled and overs completed. Fits into the umpire’s pocket.
- Seven-day timer with 2 switch programmes per day. This battery-operated system could be adapted to control mains circuits but could be built and tested with low voltages.
- Solar tracker, using sensors and stepper motors to point the device at the Sun throughout the day.
- Digital speech sampler, using a microprocessor system to record a short sample of speech and play it back on demand.
- Door lock, operated by keypad. Use of microprocessor allows easy PIN change.
- Graphic equaliser with infra-red remote control.
- Cricket scoreboard showing totals of runs and wickets. Runs are entered singly or as groups of 2, 3, 4, 5, or 6. The system could be in miniature, and battery-operated.
- Weather station data transmission system. Concentrating on digital transmission of analogue data, and subsequent checking and display. The collection of data is not part of the project.
- Stroboscope. A xenon tube was triggered at frequencies between 25 and 100 Hz. Xenon tubes need high voltages, and safety precautions need to be taken at each stage.
- Light dimming device. It fades a lamp completely in 10 minutes. There are few applications, but the problem is unusual and challenging.
- High-speed data transmission. The system stores data over a period of time and loads it as one block rapidly into a computer.
- Multichannel lamp dimmer, controlling several lamps but using only one pair of wires.
- Lighting entertaining unit. The system modifies a light display in response to music. Three frequency bands are used.
- Anemometer recorder. Measures rotation speed of c cogged ferrous wheel attached to the
anemometer shaft and then converts to a wind speed, displayed in m s$^{-1}$.

- Prototyping board with on-board regulated power supply, signal generator and debounced switches.
Appendix D

Project Assessment Criteria

The project in Unit 2528 is marked out of 78 marks and that in Unit 2531 is marked out of 90 marks according to the following criteria.

The highest mark shown is the maximum for that criterion. Intermediate marks can be awarded when appropriate.

Clarity of specification, equipment requirements, and feasibility within allocated time

6 Specified the system very clearly and completely. Kept within the limitations of the equipment available. Chose a project which could be accomplished within the allocated time.

4 Specified the system in some detail, with some regard to the limitations of the equipment available. The project was feasible within the allocated time.

2 Specified the system in broad terms. May not have taken account of the limitations imposed by the equipment available. The project may have been too ambitious for the allocated time.

0 Did not specify the system clearly enough for a realistic evaluation of the final system to be possible.

Investigation into alternative solutions via literature, IT or preliminary circuit assembly (Unit 2531 only- Synoptic)

6 Investigated at least one other solution to the problem and produced a detailed comparison with the final choice of design

4 Investigated one other way of building the system, with valid arguments in support of final choice of design.

2 Mentioned one other way in which the system could be built. Produced some valid argument to support final choice of design.

0 No mention or investigation of alternative to final choice of design.
Understanding of the operation of the circuits used

8 Demonstrated a thorough understanding of the characteristics and operation of all the circuits used and their interaction.

6 Demonstrated a good understanding of the characteristics and operation of all the circuits used.

4 Demonstrated some understanding of the characteristics and operation of all the circuits used.

2 Demonstrated some understanding of the characteristics of the circuits used, but not always of their operation.

0 Unable to demonstrate any understanding of the operation of the circuits used.

Evidence of a systematic approach, use of sub-systems, overall planning

10 Assembled and tested sub-systems separately, combined tested and working sub-systems to form the final system. Built and linked sub-systems in a logical order.

8 Assembled and tested sub-systems separately, combined tested and working sub-systems to form the final system. Did not build and link sub-systems in a logical order.

6 Assembled sub-systems separately, but did not always test them thoroughly before connecting them together to make the final system.

4 Assembled sub-systems separately, but did not test them before connecting them together to form the final circuit.

2 Assembled the whole circuit without using sub-systems, but showed some evidence of a planned approach to its assembly and testing.

0 Assembled the circuit without using sub-systems. Showed no evidence of planning.

Investigation of relevant characteristics of circuits including the final solution

8 Carefully investigated the relevant characteristics of sub-systems. Made detailed observations of the behaviour of the final system. Used appropriate techniques and measuring apparatus.

6 Investigated some characteristics of sub-systems. Made detailed observations of the behaviour of the final system. Used appropriate techniques and measuring apparatus.

4 Made detailed investigations of the behaviour of the final system. Did not always choose the most suitable techniques or measuring apparatus.

2 Made some relevant investigations of the behaviour of the final system. Did not always choose the most suitable techniques or measuring apparatus.

0 Made no investigation of relevant characteristics of the final system.
Extent to which the final solution fitted the specification

4  The final solution fitted the specification in all respects.
2  The final solution fitted the specification in some, but not all, respects.
0  The final solution did not fit the specification.

Neatness, sensible choice of layout

8  Built neat circuits with colour coded wires and logically arranged components. Positioned sub-systems in a sensible and orderly arrangement.
6  Built neat circuits with colour coded wires and logically arranged components. Poor positioning of sub-systems.
4  Built neat circuits, but components may not have always been logically arranged within a sub-system.
2  Circuits untidy with components arranged in a haphazard fashion within a discernible sub-system.
0  Circuits untidy with components arranged in haphazard fashion and no structure of sub-systems discernible.

Economy of sub-systems, appropriate use of available apparatus

10 Consistently used the most appropriate components for assembling sub-systems, considering power supply arrangements and impedance matching to other sub-systems.
8  Usually used the most appropriate components for assembling sub-systems, considering power supply arrangements and impedance matching to other sub-systems.
6  Usually used the most appropriate components for assembling sub-systems but did not always consider power supply arrangements or impedance matching to other sub-systems.
4  Assembled each sub-system without taking account of impedance matching to other sub-systems.
2  Did not use the most appropriate components for assembling most of the sub-systems.
0  Consistently failed to use the most appropriate components in the assembly of sub-systems.
Reliability of operation of final system

6 Final system behaved in a consistent fashion, was reliable and robust having no problems with loose wires or components.

4 Final system behaved in a consistent fashion, was usually reliable and had few problems with loose wires or components.

2 Final system sometimes behaved erratically, was usually reliable and had occasional problems with loose wires or components.

0 Final system did not work or often behaved erratically and was generally unreliable and unpredictable.

Elegance, brilliance, originality of system and perseverance (Unit 2531 only)

6 Final solution was one of the best possible, using the minimum number and most appropriate choice of components, performing its function in an uncomplicated fashion. The design was original work for the candidate.

4 Final solution had an appropriate choice of components and candidate persevered until it performed its function in an uncomplicated fashion. Some of the design was not original work for the candidate.

2 Final solution did not always use the most appropriate components and did not perform its function in an uncomplicated fashion. The candidate showed little perseverance in improving its performance.

0 The final solution was not original work for the candidate.

Accuracy of report as a summary of all work done

5 The report was a complete and accurate account of all work done.

4 The report was an accurate but not complete account of work done.

3 The report was a complete account of the work done, inaccurate in some details.

2 The report was not a complete account of work done and was inaccurate in some details.

1 The report was not a complete account of work done, being mostly an accurate description of the final solution.

0 The report consisted of an inaccurate description of the final solution.
Clarity of style, appropriate choice of layout and headings, use of IT

5  The report was fluently written, had a sensible structure, was easy to read and logically broken up into sections with appropriate headings.

4  The report was well-written, had a structure, was easy to read but sections were sometimes unnecessarily long. Lacked concision.

3  The report was broken into manageable sections by appropriate headings, but the style lacked clarity.

2  The report was in sections which were sometimes unnecessarily long, with appropriate headings. The style of writing made understanding difficult.

1  The report lacked structure, not being in headed sections. The style of writing made understanding difficult.

0  The report lacked structure and was very difficult to read and understand.

Clarity and accuracy of diagrams

3  Diagrams were always clear and accurate.

2  Most of the diagrams were clear and accurate.

1  Some of the diagrams were clear and accurate.

0  None of the diagrams were clear and accurate.

Evaluation of performance of final system

3  The report contained a full and honest evaluation of the final system.

2  The report contained an honest, but not full, evaluation of the final system.

1  The report contained a self-congratulatory or shallow evaluation of the final system.

0  The report contained no evaluation of the final system.

Acknowledgement of all sources of assistance

2  The report acknowledged all sources of assistance with detailed references.

1  The report only acknowledged some sources of assistance or acknowledged them in an incomplete or unclear way.

0  The report did not acknowledge any of the sources of assistance.
Appendix E

The Microprocessor

MICROPROCESSOR INSTRUCTION SET

Teachers may find the following mnemonics and explanations to be helpful when they begin their examination practice for OCR’s imaginary microprocessor in Module 2530, Control Circuits.

The microprocessor has the following registers:

- Program Counter (8 bit) PC
- Accumulator (8 bit) A
- Index register (8 bit) X

M(n) represents the contents of memory whose address is the value of the byte n.
M(X) represents the contents of memory whose address is stored in the index register.
M(FF) is an eight-bit output port; M(EF) is an eight-bit input port.

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Function</th>
<th>Mnemonic</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>3E n</td>
<td>A ← n</td>
<td>MOV A, n</td>
<td>Load the Accumulator with the data n which immediately follows the 3E (and reject the previous contents of the Accumulator)</td>
</tr>
<tr>
<td>C6 n</td>
<td>A ← A + n</td>
<td>ADD A, n</td>
<td>Add the data n which immediately follows the C6 to the data presently held in the Accumulator (and store the result in the Accumulator)</td>
</tr>
<tr>
<td>D6 n</td>
<td>A ← A - n</td>
<td>SUB A, n</td>
<td>Subtract the data n which immediately follows the D6 from the data presently held in the Accumulator (and store the result in Accumulator)</td>
</tr>
<tr>
<td>E6 n</td>
<td>A ← A</td>
<td>AND A, n</td>
<td>Perform a logical AND operation between the byte n which immediately follows the E6 and the byte presently held in Accumulator (and store result in Accumulator)</td>
</tr>
<tr>
<td>EE n</td>
<td>A ← A EOR n</td>
<td>EOR A, n</td>
<td>Perform a logical Exclusive OR operation between the byte in which immediately follows the EE and the byte presently held in Accumulator (and store result in Accumulator)</td>
</tr>
</tbody>
</table>
3A n  \[ A \leftarrow M(n) \]  MOV (n), A  Load the Accumulator with the data presently stored in the memory location whose address immediately follows the 3A (and reject the previous contents of the Accumulator)

32 n  \[ M(n) \leftarrow A \]  MOV A, (n)  Store the contents of the Accumulator at the memory location whose address immediately follows the 32 (and preserve the Accumulator contents)

7E  \[ A \leftarrow M(X) \]  MOV A, (X)  Load the Accumulator with the data presently stored in the memory location whose address is given by the contents of the X register (and reject the previous contents of the Accumulator)

77  \[ M(X) \leftarrow A \]  MOV (X), A  Store the contents of the Accumulator at the memory location whose address is given by the contents of the X register (and preserve the Accumulator contents)

86  \[ A \leftarrow A + M(X) \]  ADD A, (X)  Add the data presently stored in the memory location whose address is given by the contents of the X register to the data presently stored in the Accumulator (and store the result in the Accumulator)

96  \[ A \leftarrow A - M(X) \]  SUB A, (X)  Subtract the data presently stored in the memory location whose address is given by the contents of the X register from the data presently stored in the Accumulator (and store the result in the Accumulator)

A6  \[ A \leftarrow A \text{ AND } M(X) \]  AND A, (X)  Perform a logical AND operation between the byte presently stored in the memory location whose address is given by the contents of the X register and the byte presently stored in the Accumulator (and store the result in the Accumulator)

AE  \[ A \leftarrow A \text{ EOR } M(X) \]  EOR A, (X)  Perform a logical Exclusive OR operation between the byte presently stored in the memory location whose address is given by the contents of the X register and the byte presently stored in the Accumulator (and store the result in the Accumulator)
<table>
<thead>
<tr>
<th>Hex Code</th>
<th>Instruction</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6F</td>
<td>MOV X, A</td>
<td>Transfer the contents of the Accumulator to the X register (and reject the previous contents of the X register but preserve the Accumulator contents)</td>
</tr>
<tr>
<td>7D</td>
<td>MOV A, X</td>
<td>Transfer the contents of the X register to the Accumulator (and reject the previous contents of the Accumulator but preserve the X register contents)</td>
</tr>
<tr>
<td>C9</td>
<td>INX</td>
<td>Increment the contents of the X register by 1</td>
</tr>
<tr>
<td>C3 n</td>
<td>JMP (n)</td>
<td>Jump unconditionally to the memory location whose address immediately follows the C3</td>
</tr>
<tr>
<td>CA n</td>
<td>JZ (n)</td>
<td>Branch, if all 8 bits of the Accumulator are zero, to the memory location whose address immediately follows the CA (otherwise, move on to the next instruction)</td>
</tr>
<tr>
<td>C2 n</td>
<td>JNZ (n)</td>
<td>Branch, if all 8 bits of the Accumulator are not zero, to the memory location whose address immediately follows the C2 (otherwise, move on to the next instruction)</td>
</tr>
<tr>
<td>00</td>
<td>NOP</td>
<td>No operation, so move on to the next instruction</td>
</tr>
<tr>
<td>76</td>
<td>Halt</td>
<td>No operation, so move on to the next instruction</td>
</tr>
</tbody>
</table>
8 bit MICROPROCESSOR SYSTEM

Teachers may also find the following block diagrams of OCR’s imaginary microprocessor system to be useful for candidates taking Unit 2530, Control Circuits.

µP system as it is generally drawn in examinations:

µP system as it should be understood by candidates:
Appendix F

Mathematical Requirements

Candidates should be able use the following.

Graphical Representation

The equation of a straight line \( y = mx + c \); the significance of \( m \) and \( c \)
Plotting of simple graphs, including use of logarithmic axes
Graphical representation of \( x = Ae^{(t/\tau)} \) where \( A \) and \( \tau \) are constants
Use of equations such as \( V = V_o e^{(-t/\tau)} \) or \( V = V_o (1 - e^{(-t/\tau)}) \) and \( t = RC \ln(V_o/V) \) to evaluate quantities
Plots of \( \sin \theta \), \( \cos \theta \), \( R \sin (\theta + \phi) \)

Algebra

Manipulation of algebraic equations eg \( V = IR \) and \( G = 1 + R/R_1 \)
Inequalities and their simple algebraic manipulation
Solution of equations
Linear equations
Simultaneous equations:
\[
a_1x + b_1y + c_1 = 0 \\
a_2x + b_2y + c_2 = 0
\]

Calculus

Notation such as \( \frac{dV}{dt} \) for the rate of change of voltage.

Boolean Algebra

<table>
<thead>
<tr>
<th>AND rules</th>
<th>OR rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.1 = A</td>
<td>A + 1 = 1</td>
</tr>
<tr>
<td>A.0 = 0</td>
<td>A + 0 = A</td>
</tr>
<tr>
<td>A.A = 0</td>
<td>A + A = 1</td>
</tr>
</tbody>
</table>

De Morgan’s theorem (DMT):

if \( Q = A.B \) then \( Q = A + B \)
if \( Q = A + B \) then \( Q = A.B \)
Redundancy Theorem (RT)

\[ A + (A\cdot B) = A \]

Race hazard theorem (RHT)

If \( Q = X\cdot A + \overline{X}\cdot B \) then \( Q = X\cdot A + \overline{X}\cdot B + A\cdot B \)
Appendix G

Formulae and Symbols

The following relationships are included in the content of the specifications, either explicitly or implicitly. Candidates are expected to quote and use them as laid down in Section 5, Specification Content. * indicates that the particular relationship is required for the particular Unit.

In the question papers, candidates are expected to recall formulae included in the Specification Content in Learning Outcomes of the form ‘Recall and use the formula...’.

Learning Outcomes of the form ‘Use formulae ...(unspecified)’ require candidates to be able to apply standard formulae to the solution of problems: these formulae will not be given to candidates.

Learning Outcomes of the form ‘Use the formula...(specified)’ require candidates to be able to apply this specific relationship to the solution of a problem: this relationship will be given to candidates in the form shown in the Learning Outcomes of Section 5. No standard formula sheet will be provided.

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V = IR$</td>
<td>2526</td>
</tr>
<tr>
<td>$P = VI = I^2R = V^2/R$</td>
<td>*</td>
</tr>
<tr>
<td>Transformer, ratio of voltages = ratio of turns</td>
<td>*</td>
</tr>
<tr>
<td>Resistors in series $R_T = R_1 + R_2 + ...$</td>
<td>*</td>
</tr>
<tr>
<td>Resistors in parallel $1/R_T = 1/R_1 + 1/R_2 + ...$</td>
<td>*</td>
</tr>
<tr>
<td>Time constant = $RC$</td>
<td>*</td>
</tr>
<tr>
<td>$V$ across resistor $V = V_0e^{(-t/RC)}$</td>
<td>*</td>
</tr>
<tr>
<td>$V$ across capacitor $V = V_o(1 - e^{(-t/RC)})$</td>
<td>*</td>
</tr>
<tr>
<td>$V_{r.m.s.} = V_p / \sqrt{2}$</td>
<td>*</td>
</tr>
<tr>
<td>$I_{r.m.s.} = I_p / \sqrt{2}$</td>
<td>*</td>
</tr>
<tr>
<td>$P_{mean} = P_p/2 = V_{rms}I_{rms}$</td>
<td>*</td>
</tr>
<tr>
<td>Frequency = $1 / \text{period}$</td>
<td>*</td>
</tr>
<tr>
<td>Resonant frequency = $1/(2\pi \sqrt{LC})$</td>
<td>*</td>
</tr>
<tr>
<td>break frequency = $1/(2\pi \sqrt{RC})$</td>
<td>*</td>
</tr>
<tr>
<td>voltage gain $G = \Delta V_{OUT} / \Delta V_{IN}$</td>
<td>*</td>
</tr>
</tbody>
</table>
Symbols and abbreviations

Communications  AGC, AM, FM, rf, superhet, trf, TV, UHF, VHF

Counters, converters  bcd, lsb, msb, ADC, DAC

General  ac, CRO, CRT, dc, LDR, LED, ntc, op-amp, pd, PSU, rms.

Microprocessors  ALU, CPU, hex, RAM, ROM

Transistors  NPN, PNP, $h_{FE}$, $I_b$, $I_c$, $I_e$, FET, MOSFET, $I_{DD}$, $I_{SS}$, $V_{DS}$, $V_{GS}$, $P_{TOT}$, $V_b$, $V_g$

Units  All those abbreviations commonly used in relevant SI units

Circuit symbols  Question papers will use symbols as recommended in Signs, Symbols and Systematics, 16-19, ASE. Teachers should note that Examiners may include a circle around the symbol for a device such as transistors. The inclusion of such circles in candidates’ diagrams is optional.