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CAMBRIDGE
International Examinations

SYLLABUS

Cambridge IGCSE®
Design and Technology

0445

For examination in June and November 2016

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Changes to syllabus for 2016

This is version 2 of the syllabus, released February 2015.

- Text relating to teacher accreditation from January 2016 has been removed from page 9.

More information is available in the February 2015 update for this syllabus.

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1. Introduction

1.1 Why choose Cambridge?

Recognition

Cambridge International Examinations is the world's largest provider of international education programmes and qualifications for learners aged 5 to 19. We are part of Cambridge Assessment, a department of the University of Cambridge, trusted for excellence in education. Our qualifications are recognised by the world's universities and employers.

Cambridge IGCSE® (International General Certificate of Secondary Education) is internationally recognised by schools, universities and employers as equivalent in demand to UK GCSEs. Learn more at **www.cie.org.uk/recognition**

Excellence in education

Our mission is to deliver world-class international education through the provision of high-quality curricula, assessment and services.

More than 9000 schools are part of our Cambridge learning community. We support teachers in over 160 countries who offer their learners an international education based on our curricula and leading to our qualifications. Every year, thousands of learners use Cambridge qualifications to gain places at universities around the world.

Our syllabuses are reviewed and updated regularly so that they reflect the latest thinking of international experts and practitioners and take account of the different national contexts in which they are taught.

Cambridge programmes and qualifications are designed to support learners in becoming:

- **confident** in working with information and ideas – their own and those of others
- **responsible** for themselves, responsive to and respectful of others
- **reflective** as learners, developing their ability to learn
- **innovative** and equipped for new and future challenges
- **engaged** intellectually and socially, ready to make a difference.

Support for teachers

A wide range of materials and resources is available to support teachers and learners in Cambridge schools. Resources suit a variety of teaching methods in different international contexts. Through subject discussion forums and training, teachers can access the expert advice they need for teaching our qualifications. More details can be found in Section 2 of this syllabus and at **www.cie.org.uk/teachers**

Support for exams officers

Exams officers can trust in reliable, efficient administration of exams entries and excellent personal support from our customer services. Learn more at **www.cie.org.uk/examsofficers**

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Not-for-profit, part of the University of Cambridge

We are a not-for-profit organisation where the needs of the teachers and learners are at the core of what we do. We continually invest in educational research and respond to feedback from our customers in order to improve our qualifications, products and services.

Our systems for managing the provision of international qualifications and education programmes for learners aged 5 to 19 are certified as meeting the internationally recognised standard for quality management, ISO 9001:2008. Learn more at **www.cie.org.uk/ISO9001**

1.2 Why choose Cambridge IGCSE?

Cambridge IGCSEs are international in outlook, but retain a local relevance. The syllabuses provide opportunities for contextualised learning and the content has been created to suit a wide variety of schools, avoid cultural bias and develop essential lifelong skills, including creative thinking and problem-solving.

Our aim is to balance knowledge, understanding and skills in our programmes and qualifications to enable candidates to become effective learners and to provide a solid foundation for their continuing educational journey.

Through our professional development courses and our support materials for Cambridge IGCSEs, we provide the tools to enable teachers to prepare learners to the best of their ability and work with us in the pursuit of excellence in education.

Cambridge IGCSEs are considered to be an excellent preparation for Cambridge International AS and A Levels, the Cambridge AICE (Advanced International Certificate of Education) Group Award, Cambridge Pre-U, and other education programmes, such as the US Advanced Placement program and the International Baccalaureate Diploma programme. Learn more about Cambridge IGCSEs at **www.cie.org.uk/cambridgesecondary2**

Guided learning hours

Cambridge IGCSE syllabuses are designed on the assumption that learners have about 130 guided learning hours per subject over the duration of the course, but this is for guidance only. The number of hours required to gain the qualification may vary according to local curricular practice and the learners' prior experience of the subject.

1.3 Why choose Cambridge IGCSE Design and Technology?

The Cambridge IGCSE Design and Technology syllabus enables leaners to identify, consider and solve problems through creative thinking, planning and design, and by working with different media, materials and tools.

Candidates gain technical and design awareness as a result, and develop skills such as initiative, resourcefulness, enquiry and ingenuity. They also develop the communication skills central to design making and evaluation.

Cambridge IGCSE Design and Technology provides an ideal basis for further study and prepares learners for their future within a rapidly changing technological society.

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Prior learning

Learners beginning this course are not expected to have studied design and technology in a formal way previously.

Progression

Cambridge IGCSE Certificates are general qualifications that enable candidates to progress either directly to employment, or to proceed to further qualifications.

Candidates who are awarded grades A* to C in Cambridge IGCSE Design and Technology are well prepared to follow courses leading to Cambridge International AS and A Level Design and Technology, or the equivalent.

1.4 Cambridge ICE (International Certificate of Education)

Cambridge ICE is a group award for Cambridge IGCSE. It gives schools the opportunity to benefit from offering a broad and balanced curriculum by recognising the achievements of learners who pass examinations in at least seven subjects. To qualify for the Cambridge ICE award learners are required to have studied subjects from five groups: two languages from Group 1, and one subject from each of the remaining four groups. The seventh subject can be taken from any of the five subject groups.

Design and Technology (0445) falls into Group 5, Creative Technical and Vocational Subjects.

Learn more about Cambridge ICE at **www.cie.org.uk/cambridgesecondary2**

The Cambridge ICE is awarded from examinations administered in the June and November series each year.

1.5 How can I find out more?

If you are already a Cambridge school

You can make entries for this qualification through your usual channels. If you have any questions, please contact us at **info@cie.org.uk**

If you are not yet a Cambridge school

Learn about the benefits of becoming a Cambridge school at **www.cie.org.uk/startcambridge**. Email us at **info@cie.org.uk** to find out how your organisation can register to become a Cambridge school.

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2. Teacher support

2.1 Support materials

Cambridge syllabuses, past question papers and examiner reports to cover the last examination series are on the *Syllabus and Support Materials* DVD, which we send to all Cambridge schools.

You can also go to our public website at **www.cie.org.uk/igcse** to download current and future syllabuses together with specimen papers or past question papers and examiner reports from one series.

For teachers at registered Cambridge schools a range of additional support materials for specific syllabuses is available from Teacher Support, our secure online support for Cambridge teachers. Go to **http://teachers.cie.org.uk** (username and password required).

2.2 Resource lists

We work with publishers providing a range of resources for our syllabuses including textbooks, websites, CDs, etc. Any endorsed, recommended and suggested resources are listed on both our public website and on Teacher Support.

The resource lists can be filtered to show all resources or just those which are endorsed or recommended by Cambridge. Resources endorsed by Cambridge go through a detailed quality assurance process and are written to align closely with the Cambridge syllabus they support.

2.3 Training

We offer a range of support activities for teachers to ensure they have the relevant knowledge and skills to deliver our qualifications. See **www.cie.org.uk/events** for further information.

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3. Assessment at a glance

For Cambridge IGCSE Design and Technology candidates take three components. Candidates must take Paper 1, one of Papers 2–4 and Paper 5, which is a project. When Centres enter candidates they must indicate which optional paper (Papers 2–4) each candidate is going to take.

<table>
<tr><th colspan="3">Components

Candidates take:</th><th>Weighting</th></tr>
<tr><td colspan="3">Paper 1 Product design 1 hour 15 minutes

This is a compulsory written paper. It tests design thinking.
50 marks
Externally marked</td><td>25%</td></tr>
<tr><th>and either:</th><th>or:</th><th>or:</th><th></th></tr>
<tr><td>Paper 2 1 hour
Graphic products

This is an optional written/drawing paper.
50 marks
Externally marked</td><td>Paper 3 1 hour
Resistant materials

This is an optional written paper.
50 marks
Externally marked</td><td>Paper 4 1 hour
Systems and control

This is an optional written paper.
50 marks
Externally marked</td><td>25%</td></tr>
<tr><th colspan="3">and:</th><th>Weighting</th></tr>
<tr><td colspan="3">Paper 5 Project

The project is compulsory and is a school-based assessment.
100 marks
Internally marked/externally moderated</td><td>50%</td></tr>
</table>

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Availability

This syllabus is examined in the June examination series and the November examination series.

This syllabus is not available to private candidates.

Detailed timetables are available from **www.cie.org.uk/examsofficers**

Centres in the UK that receive government funding are advised to consult the Cambridge website **www.cie.org.uk** for the latest information before beginning to teach this syllabus.

Combining this with other syllabuses

Candidates can combine this syllabus in an examination series with any other Cambridge syllabus, except:

- syllabuses with the same title at the same level
- 7048 Cambridge O Level CDT: Design and Communication
- 6043 Cambridge O Level Design and Technology.

Please note that Cambridge IGCSE, Cambridge International Level 1/Level 2 Certificate and Cambridge O Level syllabuses are at the same level.

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4. Syllabus aims and assessment objectives

4.1 Syllabus aims

The Cambridge IGCSE Design and Technology syllabus aims to:

- develop creative thinking in areas relevant to design and technology
- apply problem solving skills to practical and technological problems
- develop the communication skills central to design, making and evaluation
- apply knowledge and understanding to the design and making of products, taking into consideration sustainability and the wider impact on society
- encourage candidates to apply learning to areas of personal interest
- develop a range of transferable skills and the attributes of the Cambridge learner
- develop the ability to make aesthetic, economic, moral and technical value judgements.

4.2 Scheme of assessment

Candidates take three components: Paper 1, plus one optional paper (Paper 2, 3 or 4) and Paper 5, the project. Papers 1–5 **all** test the content of 'Part 1' of the syllabus. In Paper 1 candidates also need to focus on their knowledge of the 'Part 2' option they have chosen.

Paper 1: Product design

This compulsory question paper tests 'Part 1' of the syllabus. Candidates answer one of three open-ended questions which assess their design abilities. Candidates will be required to complete a pre-printed response sheet which sets out specific space for each element of the question they choose. The range of questions will reflect the breadth of optional content, with one question primarily focussing on 'Resistant materials', one on 'Graphic products' and one on 'Systems and control'. Candidates are however permitted to answer any one of the questions, irrespective of their entry option.

Papers 2–4: Options

Candidates take **one** of the three optional papers (Papers 2, 3 and 4). Each of these papers tests knowledge of aspects of 'Part 1 ' of the syllabus as well as the optional subject material of 'Part 2'. Each paper has a Section A and a Section B. Section A consists of compulsory questions. Section B consists of longer structured questions: in Paper 2 candidates choose one out of two questions; in Papers 3 and 4 candidates choose one out of three questions.

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Paper 5: Project

The project is a significant part of the teaching and assessment requirements of this syllabus; it is important that candidates have the opportunity to access facilities whereby the realisation of products can be achieved.

Each candidate must complete an individual project which centres on the option they have chosen from Part 2 of the syllabus. The project area is decided by the candidate with advice as appropriate from their teacher. Cambridge does not prescribe or recommend project areas. Candidates usually work on their project over the final two terms of the course. The project is internally marked by the teacher and externally moderated by Cambridge (see Section 6.2).

Although each candidate bases their project on the option they have chosen, the nature of design and technology means that a candidate might want to include some knowledge, materials and skills from other options as well. This is permissible, but not required, and should be limited.

Candidates should produce work in the form of an A3-size folder and the 'made product'. Use of CAD/CAM is encouraged where facilities exist. However, all relevant work should still be presented in hard copy as an A3-size folder; soft copy submission is not acceptable. The folder must include sufficient photographs of the made product, showing an overall view together with detailed views of evidence which support the award of marks for project assessment criterion 6 'Product realisation'. (See 'Project assessment criteria' in Section 6.1.)

If candidates have chosen the 'Graphic products' option, their folder will contain all the preliminary design work, and their 'made product' could be in 2-dimensional or 3-dimensional form. In the case of architectural design, the folder would contain the design work, and the made product should be a well-constructed architectural 3-dimensional model, which should then be evaluated for its quality and effectiveness as a model.

Models are not appropriate as 'made products' in other contexts. For example, it is inappropriate to produce paper/card models as the final outcome for products that should be manufactured using resistant materials. Candidates must create a 'product' that can be properly tested and evaluated in the environment it is intended for.

4.3 Assessment objectives

There are three assessment objectives (AOs).

AO1 Recall, select and communicate knowledge and demonstrate understanding in design and technology including their wider effects.

AO2 Apply knowledge, understanding and skills in a variety of contexts and in designing and making products.

AO3 Analyse and evaluate products, including their design and production.

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4.4 Relationship between assessment objectives and compon

The approximate weightings allocated to each of the assessment objectives are summarised below.

Assessment objective	Paper 1	Paper 2 (either)	Paper 3 (or)	Paper 4 (or)	Paper 5	Weighting for qualification
AO1	5%	15%	15%	15%	10%	**30%**
AO2	15%	5%	5%	5%	30%	**50%**
AO3	5%	5%	5%	5%	10%	**20%**
Total	25%	25%	25%	25%	50%	**100%**

4.5 Grade descriptions

Grade descriptions are provided to give a general indication of the standards of achievement likely to have been shown by candidates awarded particular grades.The grade awarded will depend in practice on the extent to which the candidate has met the assessment objectives overall. Shortcomings in some aspects of the candidate's performance in the assessment may be balanced by better performances in others.

Grade A
Candidates:

- select and communicate detailed knowledge and demonstrate a thorough understanding of design and technology
- apply relevant knowledge, understanding and skills in a range of situations to plan and carry out investigations and tasks effectively
- test their solutions, working safely and with a high degree of precision
- analyse and evaluate the evidence available, reviewing and adapting their methods when necessary
- present information clearly and accurately, making reasoned judgements and presenting substantiated conclusions.

Grade C
Candidates:

- select and communicate sound knowledge and demonstrate an understanding of design and technology
- apply knowledge, understanding and skills in a range of situations to plan and carry out investigations and tasks
- test their solutions, working safely and with precision
- review the evidence available, analysing and evaluating some information clearly, and with some accuracy
- make judgements and draw appropriate conclusions.

Grade F
Candidates:

- select and communicate knowledge and demonstrate an understanding of basic aspects of design and technology
- apply limited knowledge, understanding and skills to plan and carry out simple investigations and tasks, with an awareness of the need for safety and precision
- modify their approach in the light of progress
- review their evidence and draw basic conclusions.

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5. Syllabus content

5.1 Part 1: Product design

Study of Part 1 is compulsory. Paper 1 (Product design) and Paper 5 (Project) specifically assess this content. Teachers should also integrate this content when teaching the optional specialist area from Part 2. Some content from Part 1 may be examined in the optional papers.

Centres and candidates are encouraged to use CAD/CAM throughout the curriculum if they have the facilities.

Part 1: Product design	
	Candidates should be able to:
Observe need/requirement	• identify and describe needs and opportunities for design and technological improvement
Design brief/specification	• analyse and produce design specifications for problems which they, or others, have identified
Identification/research	• identify the constraints imposed by knowledge, resource availability and/or external sources which influence proposed solutions • gather, order and assess information relevant to the solution of practical/technological problems • produce and/or interpret data (e.g. diagrams, flow charts, graphs, experimental and test results)
Generation of possible ideas	• generate and record ideas as potential solutions to problems using a range of techniques • identify what resources they need for solving practical/ technological problems • use a variety of media and equipment to produce models and mock-ups as a means of exploring a problem and as a means of testing the feasibility of a solution • recognise the need for continuous appraisal of their own progress, thinking and decision making, in order to provide themselves with opportunities for review • relate these judgements to the purpose of their study, in particular the specification which they set themselves
Selection/organisation	• select and develop a solution after consideration of time, cost, skill and resources • organise and plan in detail the production of the selected solution

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Evaluation	• evaluate existing products/systems, the work of others and th own work • test the performance of the product/solution against the original specification • use different methods and sources to assess the effectiveness of a product (e.g. sampling, questionnaires, interviews) • suggest any possible modification and improvements (consideration to include functional, safety, aesthetic, ergonomic and economic factors)
Implementation and realisation	• show an awareness of correct procedures for their preparation • show an awareness of the correct and accurate methods of drawing, marking out and testing • select appropriate processes for shaping, forming, cutting, joining, fitting, assembling and finishing a variety of materials
Health and safety	• show an awareness of the correct use of hand and machine tools and equipment • show a proper regard for all mandatory and other necessary safety precautions relevant to the use of a variety of tools, machines, materials and other resources • understand the responsibilities of designers to ensure that products are safe to use • understand the importance of personal safety and the safety of others when designing and making products • recognise basic safety symbols used in the workshop
Initiation and development of ideas, and recording of data	• extract relevant information from sources, interpret and record information and data
Communication of design ideas	• use technical vocabulary, number skills, colour, shading and other media to produce sketches, models, diagrams, drawings and written materials, which communicate their ideas with precision and clarity
Use of technology in design and making	• research existing products (Internet) • understand the benefits of CAD/CAM when designing and manufacturing one-off or batch production • understand how CAD can be used to generate 2D and 3D images • understand how CAD/CAM is used in industry • be aware of a variety of machines that can be controlled by computer, including miller/router/engraver, CNC lathe, milling machine, router, laser cutter • have an awareness and understanding of how computers can enhance stock control and quality control
Design and technology in society	• show awareness of the effect of design and technology activity on social, environmental and economic issues • demonstrate awareness of the role of designers, craftsmen and technologists in industry and society • take a range of human needs into account

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Practical design application	• consider how existing products meet the needs of the users • consider production manufacturing as: one-off, batch and mass production • generate design proposals: – identify the resources needed – plan the stages of manufacture – evaluate proposals against a specification – understand the relevance of function and aesthetics (in terms of the appreciation of the use of line, shape, form, proportion, space, colour and texture as appropriate to their designed solutions and the work of others) – understand the importance of anthropometrics and ergonomics – use modelling to test proposals
Environment and sustainability	• recognise that different forms of energy sources exist, namely, fossil fuels, nuclear, renewable • understand the difference between the finite and almost infinite nature of energy sources and how design can help to conserve all energy sources • use energy sources effectively and efficiently • be aware of the responsibilities of designers towards sustainability of materials and other resources • select materials based on environmental and sustainable considerations • understand the need for recycling • identify materials that can be recycled and those that cannot • understand the importance of disassembly of products and the reuse of parts • understand that products may be designed with a limited lifetime
Control	• identify the features of a control system in terms of input devices, processing elements, output devices, feedback

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5.2 Part 2: Graphic products

Graphic products is a Part 2 option. Centres and candidates can choose to study either 'Graphic products', 'Resistant materials' or 'Systems and control'.

It is a good idea to teach the following objectives in a practical way, wherever possible, and to integrate them with the content of Part 1.

This area of study aims to develop the skills that designers use within the context of their design activities in the design studio. It also aims to develop an awareness of the importance of communication and modelling techniques concerned with promotion and illustration of ideas and their interrelationship with all stages in commercial manufacture and promotion. Teachers should refer to the role that graphic products have in one or more of the following or similar areas:

- Packaging
- Promotional design
- Display
- Product design
- Manuals
- Transport
- Architectural modelling
- Corporate identity
- Interior design

Drawing equipment to be used in the examination

All candidates taking this option should have access to the following basic drawing equipment: A3 drawing board and tee square (or parallel drafting device), 30°/60° and 45° set squares, 180° protractor, pencil compass, 300mm rule, drafting pencils, coloured pencils and an eraser.

Candidates may also use templates for elliptical shapes and flow chart symbols. However, it must be noted that some examination questions require the candidate to construct ellipses and marks are awarded for evidence of construction.

Where candidates use a trammel made from folded paper or a strip of card for constructing an ellipse, this must be attached to the examination paper as evidence of construction.

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Part 2: Graphic products	
	Candidates should be able to:
Formal drawing	• demonstrate a working knowledge of appropriate British Standards, including the dimensioning of drawings and drawing to recommended scales
Orthographic projection	• identify and use both first and third angle orthographic projection (examination questions will include both first and third angle orthographic projection)
Isometric	• understand and use this form of drawing, including isometric views of circles, arcs and other curves (isometric scale is not required)
Planometric	• understand and use this form of drawing at 45° × 45° and 60° × 30°, including circles and arcs (scaling is not required)
Estimated two-point perspective	• understand and use this form of drawing using one-point and two-point starts and using perspective grids
Sectional views	• select the most suitable section and draw whole, part, revolved and removed sections
Exploded views	• draw exploded views of component parts along one axis only
Assembly drawings	• assemble given component parts into a single drawing, including parts lists
Freehand drawing	• use freehand drawing to communicate ideas, thoughts and information from written, visual and tabular data, presenting these ideas in pictorial, plane or orthographic mode
The use of appropriate and relevant geometrical constructions to determine basic shapes	• construct regular and irregular plane linear shapes, including triangles, quadrilaterals, pentagons, hexagons and octagons, and bisect, sub-divide and proportionally divide lines; construct circles, tangents and tangential arcs
Developments	• construct developments of cubes, prisms, cylinders and cones, including simple truncations
Ellipses	• construct ellipses by any accurate method, including the use of a trammel
Enlarging and reducing	• use graphical methods to enlarge/reduce a shape to fit within a given size or location • apply one-point perspective to enlarge/reduce a shape • use a graphical method to enlarge/reduce a line to a given scale or ratio
Use of instruments	• use instruments to achieve a good standard of graphical representation
Use of drafting aids	• use drawing aids including technical pens, templates, lettering and other stencils, radius aids, flexicurves (candidates can use ellipse aids and other templates in the examination, unless the examination paper states otherwise)

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Layout and planning	• select the most suitable layout to achieve visual impact and to convey information clearly and effectively
Presentation	• demonstrate the following range of techniques: – thin and thick line – light and shade to show form and mass – textural representations to illustrate a range of materials – colour rendering using a range of materials and aids • emphasise their ability to select the most relevant method to present information for a particular purpose • use clarity and good proportion to demonstrate the different modes of drawing diagrams and lettering necessary for the communication of information according to content, purpose and user • demonstrate an awareness of an ability to produce varied lettering effects by the use of: – different lettering styles – different letter spacing – dry transfer methods – stencils – computer-generated lettering
Data graphics	• produce line, pie, bar and flow charts/graphs from data provided • produce sequence drawings from data provided • show an understanding of the range and purpose of standardised signs and symbols
Reprographics	• have a knowledge of commercial printing methods such as gravure, screen printing and lithography
Materials and modelling	• use modelling appropriately to scale • have a knowledge of the following materials: paper, card, corrugated card and plastic, Styrofoam and foam board, thin plastic sheet, self-adhesive vinyl, polymorph, shape memory alloy (SMA) and thermochromics • produce a scale drawing to enable a visual model to be made • recognise and use appropriately a range of modern adhesive methods to make temporary and permanent joints in graphic products • recognise and use non-permanent joining methods including slots, arrow-tabs and flaps • recognise the use of reinforcing, fold-over locking flaps and lock rudder flaps used in packaging and display

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ICT	• understand and be aware of the use of a computer to research shapes, images and letter fonts • understand and be aware that digital images can be captured and stored on a computer • understand and be aware of the use of a computer to alter the size and area of suitable shapes, images and letters for application to a graphical product • understand that computers can output to a range of devices to give hard copy or a cut profile suitable for application to a graphical product • understand and be aware of the use of a computer to aid drawing (CAD) and manufacture (CAM)
Manufacture of graphic products	• use hand tools safely and correctly to produce prototype graphic products • understand the processes of vacuum forming and blow moulding to create blister packaging • understand the commercial processes used to cut, crease and shape materials for quantity manufacture of graphic products

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5.3 Part 2: Resistant materials

Resistant materials is a Part 2 option. Centres and candidates can choose to study either 'Graphic products', 'Resistant materials' or 'Systems and control'.

It is a good idea to teach the following objectives in a practical way, wherever possible, and to integrate them with the content of Part 1.

This area of study aims to develop the skills which designers use within the context of materials and their processing. Candidates need practical experience so that they can get a broad understanding of materials and their processing rather than an in-depth knowledge of any particular material, technology or process. This practical experience should include:

- the general physical and working properties of common construction materials (plastics, woods and metals) in relation to specific designing and making tasks
- simple comparative testing leading to the reasoned selection of materials and processes for specific design and making tasks.

Part 2: Resistant materials	
	Candidates should be able to:
Types of material	• understand the physical and working properties and application in relation to plastics, woods and metals
Smart and modern materials	• develop an awareness and understanding of 'smart' and modern materials, including: thermochromic materials; polymorph; shape memory alloy (SMA); shape memory polymer (acrylic)
Plastics	• show a working knowledge of the following: – thermoplastics (nylon, low and high density polyethylene [LDPE and HDPE], polyethylene terephthalate [PET], polyvinyl chloride [PVC], acrylic [PMMA], polystyrene [PS], polypropylene [PP], acrylonitrile-butadine-styrene [ABS]) – thermosetting plastics (polyester resin including GRP, melamine formaldehyde [MF], urea formaldehyde [UF] , phenol formaldehyde [PF] and epoxy resin)
Woods	• show a working knowledge of natural timbers and understand their classification, properties and uses • understand why timber is seasoned and how to care for timber during storage and construction • understand steaming and bending of timbers and have knowledge of adhesives' curing times and strengths • show a working knowledge of the following manufactured boards: plywood, blockboard, chipboard, hardboard and MDF • understand the advantages and disadvantages of working with manufactured boards compared with solid wood
Composites	• show an understanding of the term 'composite' and be aware of the practical applications for each of the following composite materials: – Kevlar® – carbon fibre reinforced plastic (CFRP) – glass reinforced plastic (GRP)

Kevlar is a registered tr

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Metals	• show a working knowledge of the following metals: – ferrous metals (cast iron, mild steel, stainless steel, high speed steel [HSS] and carbon steels) – non-ferrous metals (aluminium, duralumin and other common casting alloys, copper and its alloys, zinc, lead and tin) • understand how the following processes can change the molecular structure of a material making it more or less suitable for the task it has to perform: – work hardening – annealing all metals – case hardening of mild steel – hardening and tempering tool steel (HCS)
Preparation of materials	• show knowledge of available market forms, types and sizes • understand methods of cutting by use of hacksaw, guillotine, tenon saw, cross-cut saw, panel saw and portable power tools • understand the use of datum surfaces/lines/edges and be able to produce them by planing or filing • explain the preparation for machine processes and safe methods of securing materials to work surfaces, work tables, faceplates, lathe chucks and between centres on a lathe
Setting/marking out/testing	• measure and/or mark out using rule, pencil, marking knife, marker pen, scriber, try square, bevel, mitre square, centre square, dot/centre punch, dividers, inside/outside/odd-leg calipers, template, marking/cutting/mortise gauge • accurately produce datum lines by surface plate and scribing block or calipers • accurately measure using a micrometer, vernier gauge and digital caliper
Shaping	(a) Deforming/reforming • understand the following processes: bending, sand casting, die casting, lamination, vacuum forming, blow moulding, injection moulding, extrusion, press forming (b) Wastage/addition • select and perform the following forms of cutting and removal of material, and joining and adding to a material to produce the required shape, form or contour: ○ use hand snips, saws, files, basic planes and abrasive cutters ○ simple hole boring by hand or machine including pilot, clearance, tapping, countersunk and counterbored holes ○ use taps and dies for screw cutting by hand ○ use planes, chisels, gouges and rasps ○ use abrasive mops, discs and belts ○ use of centre lathe and wood turning lathe ○ use of portable power tools

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Joining and assembly	• use various methods of fabrication and fitting to join parts of products, permanently or temporarily • understand the processes of soldering, brazing , welding, riveting/ pop riveting • understand methods of carcase, stool and frame construction using permanent and temporary joints • use holding devices, formers and jigs (for sawing, drilling and bending) to assist joining and assembly • understand the use of knock-down (KD) fittings for use with manufactured boards such as chipboard, including one-piece and two-piece corner blocks, scan fittings, cam lock and leg fastenings • understand where to use a wide range of pre-manufactured components, including screws, nails, nuts, bolts, hinges and catches • understand how sizes of screws, nails,nuts and bolts are specified • be aware of a range of different adhesives to join a variety of materials and any special considerations needed relating to preparation, application, drying times and health and safety
Finishing	• understand the preparation for and application of surface treatments • be aware of a range of different finishes including oils, paints, lacquers, stains, satin polishes, dipcoating • be aware of surface finishes available for both interior and exterior use • be aware of the special finishes available that will prevent corrosion or stains, or withstand heat or liquids • understand the term ‘self-finishing’ and the processes by which some materials are self-finished • electroplating, anodising

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5.4 Part 2: Systems and control

Systems and control is a Part 2 option. Centres and candidates can choose to study either 'Graphic products', 'Resistant materials' or 'Systems and control'.

It is a good idea to teach the following objectives in a practical way, wherever possible, and to integrate them with the content of Part 1.

This area of study aims to develop the skills and knowledge used by designers within the context of a group of related technological resource areas: structures, mechanisms and electronics. Candidates need practical experience so that they can get a broad understanding of the three resource areas. By identifying how these areas interrelate, candidates can appreciate and exploit their role in designing and making controlled systems.

Part 2: Systems and control – Structures	
	Candidates should be able to:
Designing and making	• design and make working models and practical products, applying the concepts, knowledge and skills listed, and using resistant materials, components and kits • design, make and evaluate a static structure • use the principle of levers to design and make a simple machine that is structurally sound
Testing	• use a simple dial gauge to measure the deflection of simple structures • understand the use of strain gauges for testing common structural and mechanical members/components under strain
Moments (turning forces)	• define a moment as force × distance (Nm) • demonstrate an understanding of the use of moments in simple calculations relating to the loading of beams and levers
Structure and forces	• calculate and analyse simple forces using triangle and parallelogram representation; examples will include support wires, tripods, shear legs and frames • understand the design and construction of structures which withstand stress and take stationary and moving loads
Types of structure	• identify and classify both natural and man-made structures as they occur in everyday life
Types of structural member	• draw, describe and identify various types of member such as beam, strut and tie
Materials	• describe, compare and contrast the properties of the following structural materials when used in the construction of beams, frames, arches and cables: – woods, metals, stone, concrete, plastics and composites
Nature of structural members	• understand how length, shape of cross-section and material selection affect performance

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Joints in structures	• apply sound judgement when selecting the appropriate metho joining materials of solid and hollow cross section • select and use different methods of reinforcing such as gussets, ribs, braces and laminating
Framed structures	• recognise frames in use and identify the use of triangulation to establish rigidity
Applied loads and reactions	• apply the concept of equilibrium as a result of applied load and reaction • understand what is meant by the following terms and their relationship to structural design: tension, compression, shear, bending, torsion and static load (simple examples only)
Forces	• understand Stress = $\frac{\text{force}}{\text{cross sectional area}}$ • understand Strain = $\frac{\text{change in length}}{\text{original length}}$ • draw and interpret a typical stress/strain graph for mild steel and identify the important features on this graph • understand the significance of these features to structural design • understand the term Factor of Safety and its importance to structural design

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Part 2: Systems and control – Mechanisms	
	Candidates should be able to:
General concepts	• explain and use the following terms correctly: load, effort, fulcrum, mechanical advantage, velocity ratio and efficiency
Levers	• identify and sketch simple examples of first, second and third order levers, and associated linkages
Transmission of motion	• select appropriately and list the factors influencing the choice of the following for practical applications: – gears: ○ spur, bevel, worm, rack and pinion – belts and pulleys: ○ flat, toothed, round and vee belts and pulleys ○ sprockets and chains ○ standard systems to maintain tension in drive belts and chains • calculate simple gear ratios and transmission speed • determine the Mechanical Advantage (MA), Velocity Ratio (VR), efficiency and rotational direction for the following: – wheel and axle, screw jack, compound pulley and gear arrangements • understand the: – basic principles of operation of pneumatic and hydraulic systems – applications of pneumatic control for providing reciprocating motion – integration of electronic and pneumatic systems
Energy	• describe the power sources used to drive mechanical systems and recognise a battery as an electrical energy storage/conversion device • understand the safety considerations for power sources • understand the energy costs of powering systems and how it is possible to reduce the potential energy demand through good design and manufacture
Bearings and lubrication	• recognise the need to reduce friction between two surfaces by design, and describe the types of lubrication, and other methods of application for different situations • compare and contrast the use of plain, roller and ball bearings, and give reasons for their suitability for specific operational conditions
Conversion of motion	• recognise and give examples of the following types of motion: rotary, linear, reciprocating and oscillating • understand the terms crank, cam, follower, dwell, stroke, screw thread, pitch • compare and select appropriately crankshafts, crank/slider mechanisms, rack and pinion, ratchet and pawl, eccentrics, simple cams and screw threads as methods of converting motion from one type to another

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Part 2: Systems and control – Electronics	
	Candidates should be able to:
Basic concepts	• use correct symbols and conventions when drawing circuit diagrams • describe the operation of a circuit in terms of conventional current flow • identify and compare conductivity and insulation when selecting materials • understand and apply units used to measure current, voltage, resistance and capacitance, including multiple and sub-multiple units • understand the relationship between current, voltage and resistance (Ohm's Law) and use to calculate the value of a current limiting resistor • use ammeters, voltmeters and multimeters to measure current, voltage and resistance • perform simple power calculations using P = VI
Circuit building techniques	• design and construct printed circuit boards (PCBs) • make use of: – soldering, other methods of connection, appropriate tools • recognise appropriate health and safety considerations
Switches	• understand the action and application of the following common switches: – toggle, push button (PTM/PTB), micro, rotary and reed • understand the terms normally closed (NC), normally open (NO), common connection (C), single pole single throw (SPST) and double pole double throw (DPDT) in relation to switches and relays • use relays to switch higher voltage circuits for motors, solenoids, etc. • construct and draw circuits which use a two pole change-over relay to give motor reverse control and latched (memorised) switching
Resistors	• make use of the resistor colour code to determine the value and tolerance of a resistor and to select the nearest suitable value • draw circuit diagrams and perform calculations for resistors in series and parallel • understand the term potential divider and perform calculations to determine values of resistance and voltage in potential divider circuits
Transistors	• describe the operation of transistors in terms of the base bias voltage controlling the collector emitter circuit • select appropriately the use of NPN transistors as switches in circuits

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Diodes	• understand the use of a diode as a one way conductor, and its use in a relay circuit to protect against back emf • use LEDs in circuits and be able to calculate the value of a suitable current limiting resistor to protect LEDs • understand the function of 7 segment displays
Transducers	• understand the use of the following transducers: LDR, thermistor, strain gauge
Capacitors	• explain the charging and discharging of a capacitor, with the aid of diagrams/graphs • understand the differences between, and applications for polarised and non-polarised capacitors
Time delay circuits	• construct and draw circuit diagrams for time delay circuits (monostable and astable) using capacitors, resistors, transistors and the 555 timer IC • understand the use of programmable ICs (PICs) for time delays • calculate time delays from a given formula • use graphs and data to be able to select components to achieve a desired time delay
Logic gates and operational amplifiers	• understand the use of logic gates (AND, OR, NAND, NOR, NOT) and truth tables for simple logic control systems • demonstrate knowledge of CMOS ICs, e.g. 4000 series • use an Operational Amplifier (Op Amp) to compare voltages • give examples of the use of logic control systems in everyday life, e.g. heating control, traffic lights, environmental control in a greenhouse, etc.

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6. Project assessment

6.1 Project assessment criteria

Criterion	Description	Mark range	Maximum mark
1. Identification of a need or opportunity with a brief analysis leading to a design brief	Consideration of both the design need and the intended user(s) leading to a clear design brief.	4–5	5
	Detailed consideration of the design need or the intended user(s) leading to a design brief.	2–3	
	A statement of what is to be made.	1	
	No rewardable response.	0	
2. Research into the design brief resulting in a specification	Thorough research of the design brief with relevant data identified and collected. Analysis of the research leading to a detailed and justified specification for the intended product.	8–10	10
	Meaningful research of the design brief with some data identified. A specification including key features of the intended product.	4–7	
	Limited examination of the design brief with a specification identifying some basic requirements.	1–3	
	No rewardable response.	0	
3. Generation and exploration of design ideas	A wide range of different, appropriate solutions with imaginative interpretation. Detailed evaluation of ideas and consideration of the requirements of the specification.	14–20	20
	A range of appropriate solutions proposed. Ideas examined with evaluations leading to the identification of possible ideas for development.	8–13	
	A limited range of ideas with a tendency to focus on a single concept. Little or no evaluation of ideas.	1–7	
	No rewardable response.	0	
4. Development of proposed solution	Appropriate modelling and trialling resulting in reasoned decisions about form, materials, construction/production methods and other items.	11–15	15
	As a result of investigation, appropriate decisions made about form, materials and construction/ production methods. Evidence of modelling and trialling.	6–10	
	Some decisions made about form, materials and/ or construction methods.	1–5	
	No rewardable response.	0	

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Criterion	Description	Mark range	Maximum mark
5. Planning for production	Clear and detailed planning showing an effective order for the sequence of operations. Drawings and other information give full details of the final product.	7–10	10
	A simple plan showing awareness of the main processes involved. A clear working drawing showing overall layout and major dimensions.	4–6	
	Limited evidence of any forethought. A working drawing with little detail.	1–3	
	No rewardable response.	0	
6. Product realisation	The product will be completed to a high standard of outcome with precision and accuracy. It will meet fully the requirements of the product specification.	21–30	30
	The product may have some minor inaccuracies and blemishes but will be complete and function as intended.	11–20	
	The product will exhibit a reasonable standard of outcome, be mainly complete and satisfy some aspects of the specification.	1–10	
	No rewardable response.	0	
7. Testing and evaluation	Objective testing with reference to the specification and user. Clear identification of strengths and weaknesses of product leading to detailed and meaningful conclusions and proposals for further development.	7–10	10
	Appropriate reporting and/or comment on simple testing. Reference to the specification with some evidence of identification of strengths and weaknesses of product.	4–6	
	Little or no evidence of testing. General overall appraisal with little reference to the specification.	1–3	
	No rewardable response.	0	

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6.2 Moderation

Internal moderation

When more than one teacher in a Centre is making internal assessments, the Centre must make arrangements for all candidates to be assessed to a common standard.

The internally moderated marks for all candidates must be recorded on the Coursework Assessment Summary Form. This form, and the instructions for completing it, may be downloaded from **www.cie.org.uk/samples**. The database will ask you for the syllabus code (i.e. 0445) and your Centre number, after which it will take you to the correct form. Follow the instructions when completing the form.

The Centre assessments will then be moderated externally.

External moderation

Cambridge carries out external moderation of internal assessment.

The deadlines and methods for submitting internally assessed marks and coursework samples are in the *Cambridge Administrative Guide* available on our website.

Centres should keep all records and supporting written work until after publication of results.

Centres must not send made products to Cambridge for moderation. However, folders must include sufficient photographs of the made product, showing an overall view as well as detailed views of evidence, to support the award of marks for assessment criterion 6 'Product realisation'.

6.3 Resubmission of coursework and carrying forward internally assessed marks

Information about resubmission of coursework and carrying forward internally assessed marks can be found in the *Cambridge Administrative Guide*.

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7. Other information

Equality and inclusion

Cambridge International Examinations has taken great care in the preparation of this syllabus and assessment materials to avoid bias of any kind. To comply with the UK Equality Act (2010), Cambridge has designed this qualification with the aim of avoiding direct and indirect discrimination.

The standard assessment arrangements may present unnecessary barriers for candidates with disabilities or learning difficulties. Arrangements can be put in place for these candidates to enable them to access the assessments and receive recognition of their attainment. Access arrangements will not be agreed if they give candidates an unfair advantage over others or if they compromise the standards being assessed.

Candidates who are unable to access the assessment of any component may be eligible to receive an award based on the parts of the assessment they have taken.

Information on access arrangements is found in the *Cambridge Handbook* which can be downloaded from the website **www.cie.org.uk/examsofficer**

Language

This syllabus and the associated assessment materials are available in English only.

Grading and reporting

Cambridge IGCSE results are shown by one of the grades A*, A, B, C, D, E, F or G indicating the standard achieved, A* being the highest and G the lowest. 'Ungraded' indicates that the candidate's performance fell short of the standard required for grade G. 'Ungraded' will be reported on the statement of results but not on the certificate. The letters Q (result pending), X (no results) and Y (to be issued) may also appear on the statement of results but not on the certificate.

Entry codes

To maintain the security of our examinations, we produce question papers for different areas of the world, known as 'administrative zones'. Where the component entry code has two digits, the first digit is the component number given in the syllabus. The second digit is the location code, specific to an administrative zone. Information about entry codes can be found in the *Cambridge Guide to Making Entries*.

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