GCE MARKING SCHEME

SUMMER 2016

DESIGN & TECHNOLOGY
DT3 - SYSTEMS AND CONTROL TECHNOLOGY
1113/03

INTRODUCTION

This marking scheme was used by WJEC for the 2016 examination. It was finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conference was held shortly after the paper was taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conference was to ensure that the marking scheme was interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conference, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about this marking scheme.

GCE DESIGN & TECHNOLOGY
DT3 - SYSTEMS AND CONTROL TECHNOLOGY

SUMMER 2016 MARK SCHEME

SECTION A

Answer **three** *questions from this section.*
This section is designed to demonstrate your **breadth** *of knowledge in Systems & Control Technology.*
Each question carries 8 marks.

1. (a) Explain the term market segmentation.

(b) State the reasons why designers should be aware of market segmentation in relation to designing specific products.

(a) Market segmentation is the process of dividing a broad target market into subsets of consumers. The consumers may have similar needs and priorities so that designers and researchers can then implement strategies to target them. **[4]**

(b) The designers should be aware of the market segment that they are designing for:

- so that they are aware of the possible market size;
- what the share of that market is likely to be;
- who are the potential purchasers;
- what are the expectations of the market;
- positioning to achieve a marketing plan objective;
- develop product differentiation strategies;
- involving specific products or product lines depending on the specific demand of the target segment.

Note: the response here should relate to specific named products. **[4]**

2. Describe the benefits and limitations of using CAD when developing control systems for products.

Computer Aided Design (CAD) can be used at a variety of points within the development of control systems.

Typical benefits include:

- Quick construction of concepts (by those skilled in the art)
- Ability to save progress, communicate files globally.
- Efficient testing, modification and fault finding and simulation facilities.
- Virtual components used, no need for physical resources.
- Mathematical analysis and calculations can often be generated.
- Destructive testing can be undertaken.
- CAD files can be converted into other file types e.g. CAM machining data, rapid prototyping actions, CNC machining files.
- Can streamline lead in time.
- Pre made 'selectable' components or sub systems can be used which speeds up modelling process.

Typical limitations include:

- Lack of 'realistic' testing – virtual simulation only provided.
- CAD requires an expensive investment initially and training of skilled workers.
- CAD can often provide 'theoretical' performance and the 3D result may differ.
- Mistakes / issues can occur when files are converted e.g. Yenka circuits converted into pcb masks often require checking / amending as mistakes are generated. **[8]**

3. The use of ICT has a significant effect on the design and manufacture of products.

(a) Explain the benefits of ICT in pre-production prototyping.

(b) Explain the benefits of ICT within stock control.

Benefits: Pre-production prototypes

(a) Identification of design flaws

- Testing hypotheses – will a particular mechanism work
- Speed of creating an accurate 3D prototype
- Plan for part or component production
- Illustration when discussions with a client
- Test the market in order to gather opinions/data
- Enabling a shorter lead in time for the product to market
- Testing ergonomic features
- Carry out materials test
- The designer can visualise scale, evaluating form and location (also the use of animated images)
- Calculate production methods or the best way to manufacture. **[4]**

Benefits: ICT within Stock Control

(b) If a manufacturing business does not manage its stock well, it will start to lose money, or lose profits. Benefits therefore:

- An item of stock will not run out and the whole manufacturing process can carry on.
- Customers continue to be able to buy, and the company able to sell.
- Not too much of a stock item is allowed to build up, which wastes the money used to make or buy the item, and costs money to store the item.
- There will be the minimum amount of stock waiting to be used in the production process. **[4]**

4. Explain how quality standards which are developed by the BSI (British Standards Institute) and ISO (International Organisation for Standardisation) have a positive effect on two specific products.

Quality standards are an agreed, repeatable way of doing something. It is a published document that contains a technical specification or other precise conditions designed to be used consistently as a rule, guideline, or definition.

Standards help to make life simpler and to increase the reliability and the effectiveness of many goods and services in use. Standards are created by bringing together the experience and expertise of all interested parties such as the producers, sellers, buyers, users and regulators of a particular material, product, process or service.

Positive Effects:

They are based around consumer confidence by the display of the 'kite mark' or specific certification labels relating to child safety, electrical or the construction of products.

A CE mark is a manufacturer's claim that its product meets specified essential safety requirements set out in relevant European directives.

The following categories of products require CE marking if sold within the EU and responses may make reference to these:

- toys
- electrical products
- construction products
- pressure vessels
- telecommunications equipment
- medical devices
- machinery, equipment and safety components
- personal protective equipment
- satellite station equipment
- gas appliances
- pressure equipment
- appliances
- non-automatic weighing instruments and equipment
- measuring instruments
- recreational craft
- lift machinery
- equipment and protective systems for explosive atmospheres
- marine equipment
- safety components and subsystems for incorporation into cableway installations.

[8]

5. Describe in detail two methods of prototyping electronic control systems in a school workshop naming specific tools and equipment required.

Two different methods are required.

Breadboard / protobloc – this method is a traditional and well used process where components are plugged into specific holes in order to provide a complete system without 'joining' components with solder. The breadboard, components and circuit diagram are resources required. Short lengths of single core wire are often needed to 'jump' from one component to another, or from row to row on the breadboard. A multi meter is often useful to check continuity, test voltage, current or resistance at various parts of the system, or to check values acting across individual components when or before they are inserted into the breadboard. On completion, the system is tested, and the function is analysed. Components may beremoved, repositioned, or replaced so circuits can be developed. This is generally an early prototyping method.

Stripboard – a single sided copper faced board can be used to solder components in place. Holes in the stripboard are arranged in a horizontal format so that tracks conduct across the stripboard to join components. The soldering makes this a permanent method of prototyping which is generally a final pre-production prototype. Stripboard is available in a range of stock sizes and can be cut to the required size. A variety of pliers, cutters and wire strippers will be needed. A soldering iron, stand and solder will be required to connect components to the stripboard. Again a multimeter is useful for measuring specific units / connections. A stripboard cutter is often needed to break copper tracks for parts of the circuit that should not connect. **[8]**

SECTION B

Answer **three** *questions from this section.*
This section is designed to demonstrate your **breadth** *of knowledge in System and Control Technology.*
Each question carries 8 marks.

6. Explain what you understand by qualitative and quantitative testing in relation to the selection of materials when developing products.

Quantitative testing *of materials involves using some form of calibrating device to ascertain the response of materials to a particular force or range of forces*.

This can be undertaken by using scientific measuring instruments such as a tensometer or a hardness tester. Materials may also be subjected to qualitative testing by devising 'fair' tests that ascertain the ability of a particular component or the product to be able to perform reliably.

Quantitative testing are objective, measurable criteria, which can be assessed against specific performance measurable objectives.
Marks allocated with a full description with any of the following examples:

The material must weigh no more than…..
The material used must be light enough to….
Related to material hardness, malleability, ductility…..

Qualitative testing *of materials are used primarily to define a problem and generate hypotheses. They can be better than quantitative testing - understanding what drives and motivates behaviour.*

They are very valuable for exploring an issue and are used by almost all researchers at various points during large research campaigns.

Qualitative testing will reflect the intended quality of certain defined aspects of a material's specification. They are a more subjective form of criteria.

Marks allocated with a full description with any of the following examples:

The material must be aesthetically pleasing…
Material used must be recyclable….
The material must be bright…… **[8]**

7. (a) Describe, using diagrams, the 'systems approach' to problem solving. **[4]**

(b) For a named product or process, illustrate how the stages can be presented in the form of a flowchart. **[4]**

The systems approach refers to the INPUT, PROCESS, OUTPUT method where individual components or sub systems are placed simply within a block diagram to allow the designer to problem solve effectively by focussing holistically on certain aspects of the control system. This approach 'breaks down' problems into more manageable parts for designers.

Responses must refer to the named product / process. A flowchart complete with terminal boxes, operation / commands, and decision boxes should be presented, complete with feedback loops, yes / no feedback strands. More complex systems may include counting, sub routines, macros, interrupt commands etc.

8. Describe a five step risk assessment plan appropriate for a named manufacturing process.

I. Look for the hazard (being anything which may cause harm)
II. Decide who / what may be harmed and how?
III. Evaluate the risks and decide whether existing precautions are adequate or whether more needs to be done. Risk is the chance, high or low, that somebody will be harmed by the hazard.
IV. Record the findings.
V. Review the assessments and revise if necessary.

The 5 stages in the **incorrect** order gain a maximum 5 marks
Single words or very short phrases can be given credit – up to a maximum of 4 marks. **[8]**

9. Describe the material properties of a named semi-conductor that make it suitable for use in a specific product manufactured during your studies. [8]

A semiconductor is a material which has electrical conductivity between that of a conductor such as copper and that of an insulator such as glass. Semiconductors are the foundation of modern electronics, including transistors, solar cells, light-emitting diodes (LEDs), quantum dots and digital and analog integrated circuits. An increased knowledge of semiconductor materials and fabrication processes has made possible continuing increases in the complexity and speed of integrated semiconductor devices.

The electrical conductivity of a semiconductor material increases with increasing temperature, which is behaviour opposite to that of a metal. Semiconductor devices can display a range of useful properties such as passing current more easily in one direction than the other, showing variable resistance, and sensitivity to light or heat. Because the electrical properties of a semiconductor material can be modified by controlled addition of impurities, or by the application of electrical fields or light, devices made from semiconductors can be used for amplification, switching, and energy conversion.

Current conduction in a semiconductor occurs through the movement of free electrons and "holes", collectively known as charge carriers. Adding impurity atoms to a semiconducting material, known as "doping", greatly increases the number of charge carriers within it. When a doped semiconductor contains mostly free holes it is called "p-type", and when it contains mostly free electrons it is known as "n-type". The semiconductor materials used in electronic devices are doped under precise conditions to control the location and concentration of p- and n-type dopants. A single semiconductor crystal can have many p- and n-type regions; the p–n junctions between these regions are responsible for the useful electronic behaviour.

Some of the properties of semiconductor materials were observed throughout the mid 19th and first decades of the 20th century. Development of quantum physics in turn allowed the development of the transistor in 1948. Although some pure elements and many compounds display semiconductor properties, silicon, germanium, and compounds of gallium are the most widely used in electronic devices.

The properties of the named components (typically transistor, thyristor, IC) will need to be related to the use of this component in practice.

10. (a) Explain how concurrent engineering is used within product development.

(b) Explain how reverse engineering is used in the design and development of products.

Concurrent Engineering [4]

Concurrent engineering, also known as simultaneous engineering, is a method of designing and developing products, in which the different stages run simultaneously, rather than consecutively. It decreases product development time and also the time to market, leading to improved productivity and reduced costs

- Employs simultaneous, rather than sequential, processes
- Completing tasks in parallel
- Product development can be accomplished more efficiently and at a substantial cost savings
- Concurrent engineering allows for design and analysis to occur at the same time, and multiple times, prior to actual deployment
- Emphasizes teamwork
- Allows for employees to work collaboratively on all aspects of a project from start to finish
- Reduces the time required to bring a new product to the market

Reverse Engineering [4]

Involves taking something (e.g., a mechanical device, electronic component, or software program) apart and analysing its workings in detail to be used in maintenance, or to try to make a new device or program that does the same thing.

Reverse Engineering

- The process of discovering the technological principles of a product, device or system
- Analysis of its structure and form
- Take something apart and analyse its workings (mechanical, electrical or software)
- Product development can be accomplished more efficiently and at substantial cost savings.

SECTION C

Answer **two** *questions from this section.*

Your answers should be substantial and show the **depth** *of your knowledge in Product Design*

Each question carries 26 marks.

Level 1 **0-9**	• Candidate has a simplistic knowledge of the issues associated with the question. • The use of terminology and technical language is basic. • The candidate has little understanding of the general elements of industrial and commercial practices, with little knowledge of ICT in manufacturing systems if appropriate to the question. • The candidate has limited knowledge of the form and function of products. • The candidate will express ideas clearly, if not always fluently. Answers may deviate from the question or not be relevant. • Grammar, punctuation and spelling may be weak impacting on effective communication.
Level 2 **10-14**	• The candidate has a basic understanding of the issues associated with the question. • The use of terminology and technical language is variable. • The candidate understands the general elements of industrial and commercial practices related to manufacturing systems and some aspects of ICT in production. • The candidate has some general knowledge of the form and function of a product, trends and styles of products. Environmental, cultural and/or ethical/moral. These aspects are not always considered. • The candidate will express straightforward ideas clearly, if not always fluently. Answers may deviate from the question or be weakly presented. • There may be some errors of grammar, punctuation and spelling but is still able to communicate the issues.
Level 3 **15- 20**	• The candidate demonstrates a clear understanding of the issues associated with the question. • The use of terminology and technical language is reasonably accurate. • The candidate understands the general elements of industrial and commercial practices related to manufacturing systems and is aware of aspects of ICT in production. • The candidate has demonstrated a knowledge of the form and function of a product, trends and styles of products reflecting environmental, cultural and/or ethical/moral issues. These aspects are considered. • The candidate will express moderately complex ideas clearly and fluently, through well linked sentences and paragraphs. Answers will be generally relevant and structured. • There may be occasional errors of grammar, punctuation and spelling.
Level 4 **21-26**	• The candidate demonstrates a specific ability to analyse questions, takes into account of a wide range of factors and has a clear understanding of the issues associated with the question. • Uses correct terminology and technical language. • The candidate understands the main feature of industrial and commercial practices related to manufacturing systems including the use of ICT and stages of production. • Candidate has developed a detailed knowledge of the form and function of a product, trends and styles of products. Environmental, cultural and/or ethical /moral issues. These aspects are considered where appropriate. • The candidate will express complex ideas extremely fluently. Sentences and paragraphs will follow on from each other smoothly and logically. Answers will be consistently relevant and structured. • There will be few, if any, errors of grammar, punctuation and spelling.

Marks are awarded according to the four levels within the assessment criteria. These criteria are best fit and if a candidate has most of the aspects within a level then the candidate can be considered for marks towards the higher end of the band. If there are some features that are weak or missing but overall the response matches many of the descriptors then the candidate could be considered for marks in the middle of the level. Candidates may be awarded marks at the bottom of the level if they have most of the descriptors in the previous level and one or two in the next level.

11. "Truly elegant design incorporates top-notch functionality into a simple, uncluttered form" ***(David Lewis 2006)***

Discuss how this statement is relevant to the work of a contemporary designer and **the impact of the products that he / she has designed.**

This question requires an answer in essay form which assesses the way a particular contemporary designer has impacted upon the design of the particular product (an elegant, simple and uncluttered form). Have the products influenced other developments / products?

The answer should seek to identify a specific product or range of products attributed to the chosen designer and to examine the development brought about by the designer. The candidate should go on to examine styling details and their development and comment upon the styling developments, form and design simplicity and how these elements have impacted on the overall design of the product. **[26]**

12. Describe the benefits and effects that programmable micrcontrollers have on the success of a particular product in terms of form, function and reliability.

Programmable microcontrollers (PICs) offer a variety of benefits and the effect of using PICs in products include:

- PIC ICs are very small and compact thus can be used as space saving devices.
- PIC ICs are mounted into 8 Pin DIL sockets and can be removed from pcbs easily to be reused, recycled or reprogrammed.
- PICs are cost effective solutions combining many other components that will no longer be required.
- PICs have RAM and can store large amounts of data
- PIC are very reliable and can offer effective function repeatedly
- PIC ICs can control a variety of inputs and outputs in parallel.
- PIC IC are powered using low voltage cells which make them efficient and sustainable compared to other devices.
- PICs can perform a variety of different functions in parallel, promoting multi function / collective tasks.
- PIC are relatively simple to program, a variety of systems are available to facilitate this.
- PICs can be used to drive larger systems (with relays) **[26]**

13. Describe the benefits of planned obsolescence within the life cycle of specific products to the consumer and to the manufacturer.

Planned obsolescence is when a product is deliberately designed to have a specific life span. This is usually a shortened life span. The product is designed to last long enough to develop a customer's lasting need. The product is also designed to convince the customer that the product is a quality product, even though it eventually needs replacing. In this way, when the product fails, the customer will want to buy another, up to date version.

Benefits to consumer: costs are usually low, easily replaced (no need for repairs), possible to keep up with developing technology.

Benefits to the manufacturer: cost of production is low, little or no repairs necessary, life cycle is short, known and secure market. **[26]**

14. Sustainability and energy efficiency can often be driving forces for designers of control systems for products.

Discuss how sustainable and energy efficient control systems have impacted on the success of named products, and the influence this has had on the market. [26]

Sustainability and energy efficiency can be driving forces in product development. Many products are revitalised to include more sustainable materials, components, control systems and to function with lower voltage power supplies. Typical responses may include mobile phone, ipod, laptop, netbook or tablet devices where battery power has improved, or where components (such as retina displays / LED technology has developed) provide less energy consumption improving performance quality or duration.

LED technology has influences television, camera and projector industry including light bulb components, where the introduction of LED has replaces TFT . rear projection, saving space, requiring less material and making efficiency savings in production costs, materials and pollution. Life expectancy of these products has increased therefore creating an extended life cycle and reducing waste. Typical LED light bulbs provide 35 - 50 Watts when energy consumption is limited to 5 - 12w. There is also very little energy loss due to heat. The automotive industry provides exemplars of daytime running lights using LED technology.

Sustainability and energy efficiency has influenced the market by provoking savings from all designers and manufacturers of products. There are legal, moral and ethical issues which may be included, but also the success of products directly influences competitors and this acts as a driving force to improve next generation products.

[26]

15. Describe the process of quality control and quality assurance and discuss their importance to the manufacturer, consumer and the environment.

Quality Control
Checks at points on the production line for accuracy and safety of product or components. Meet consumer and environmental expectations.

Importance to:

Manufacturer
Quality control methods: dimensional accuracy (tolerances), dimensional accuracy may be checked with a gauge or measuring tool (micrometer, vernier etc). Quality of materials (visual marks or blemishes) appearance and finish, durability. The use of CAD/CAM ensuring quality.

Candidates may refer to checks made on production machinery rather than a test on the product itself.

Consumer
Important to the consumer because of confidence in the product or manufacturer, aspects of safety important to the consumer, health aspects.

The Environment
Efficiency, producing little waste or emissions, recycling possibilities and consumer safety.

Quality Assurance
In developing products and services, quality assurance is any systematic process of checking to see whether a product or service being developed is meeting specified requirements.

Importance to:

Manufacturer
Principles included in Quality Assurance are: "Fit for purpose", the product should be suitable for the intended purpose; and "Right first time", mistakes should be eliminated.

Consumer
A quality assurance system is said to increase customer confidence and a company's credibility, to improve work processes and efficiency, and to enable a company to better compete with others.

The Environment
Monitoring emissions to air, land and water and encouraging manufacturing to manage their impact on the environment and reducing and managing waste. **[26]**