Diploma Programme

Design technology guide

First assessment 2027

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IB mission statement

The International Baccalaureate aims to develop inquiring, knowledgeable and caring young people who help to create a better and more peaceful world through intercultural understanding and respect.

To this end the organization works with schools, governments and international organizations to develop challenging programmes of international education and rigorous assessment.

These programmes encourage students across the world to become active, compassionate and lifelong learners who understand that other people, with their differences, can also be right.

IB learner profile

The aim of all IB programmes is to develop internationally minded people who, recognizing their common humanity and shared guardianship of the planet, help to create a better and more peaceful world.

As IB learners we strive to be:

INQUIRERS
We nurture our curiosity, developing skills for inquiry and research. We know how to learn independently and with others. We learn with enthusiasm and sustain our love of learning throughout life.

KNOWLEDGEABLE
We develop and use conceptual understanding, exploring knowledge across a range of disciplines. We engage with issues and ideas that have local and global significance.

THINKERS
We use critical and creative thinking skills to analyse and take responsible action on complex problems. We exercise initiative in making reasoned, ethical decisions.

COMMUNICATORS
We express ourselves confidently and creatively in more than one language and in many ways. We collaborate effectively, listening carefully to the perspectives of other individuals and groups.

PRINCIPLED
We act with integrity and honesty, with a strong sense of fairness and justice, and with respect for the dignity and rights of people everywhere. We take responsibility for our actions and their consequences.

OPEN-MINDED
We critically appreciate our own cultures and personal histories, as well as the values and traditions of others. We seek and evaluate a range of points of view, and we are willing to grow from the experience.

CARING
We show empathy, compassion and respect. We have a commitment to service, and we act to make a positive difference in the lives of others and in the world around us.

RISK-TAKERS
We approach uncertainty with forethought and determination; we work independently and cooperatively to explore new ideas and innovative strategies. We are resourceful and resilient in the face of challenges and change.

BALANCED
We understand the importance of balancing different aspects of our lives—intellectual, physical, and emotional—to achieve well-being for ourselves and others. We recognize our interdependence with other people and with the world in which we live.

REFLECTIVE
We thoughtfully consider the world and our own ideas and experience. We work to understand our strengths and weaknesses in order to support our learning and personal development.

The IB learner profile represents 10 attributes valued by IB World Schools. We believe these attributes, and others like them, can help individuals and groups become responsible members of local, national and global communities.

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Contents

Purpose of this document

This publication is intended to guide the planning, teaching and assessment of design technology in schools. Subject teachers are the primary audience, although it is expected that teachers will use the guide to inform students and parents about the subject.

This guide can be found on the subject page of the Programme Resource Centre at resources.ibo.org, a password-protected website designed to support International Baccalaureate (IB) teachers. It can also be purchased from the IB store at store.ibo.org.

Additional resources

Additional publications such as specimen papers and markschemes, teacher support materials (TSM), subject reports and grade descriptors can also be found on the Programme Resource Centre. Past examination papers as well as markschemes can be purchased from the IB store.

Teachers are encouraged to check the Programme Resource Centre for additional resources created or used by other teachers. Teachers can provide details of useful resources, for example: websites, books, videos, journals or teaching ideas.

Acknowledgement

The IB wishes to thank the educators and associated schools for generously contributing time and resources to the production of this guide.

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The Diploma Programme

The Diploma Programme (DP) is a rigorous pre-university course of study designed for students in the 16 to 19 age range. It is a broad-based two-year course that aims to encourage students to be knowledgeable and inquiring, but also caring and compassionate. There is a strong emphasis on encouraging students to develop intercultural understanding, open-mindedness, and the attitudes necessary for them to respect and evaluate a range of points of view.

The Diploma Programme model

The course is presented as six academic areas enclosing a central core (see figure 1). It encourages the concurrent study of a broad range of academic areas. Students study two modern languages (or a modern language and a classical language), a humanities or social science subject, an experimental science, mathematics and one of the creative arts. It is this comprehensive range of subjects that makes the DP a demanding course of study designed to prepare students effectively for university entrance. In each of the academic areas students have flexibility in making their choices, which means they can choose subjects that particularly interest them and that they may wish to study further at university.

Figure 1

Diploma Programme model

Choosing the right combination

Students are required to choose one subject from each of the six academic areas, although they can, instead of an arts subject, choose two subjects from another area. Normally, three subjects (and not more than four) are taken at higher level (HL), and the others are taken at standard level (SL). The IB recommends 240 teaching hours for HL subjects and 150 hours for SL. Subjects at HL are studied in greater depth and breadth than at SL.

At both levels, many skills are developed, especially those of critical thinking and analysis. At the end of the course, students' abilities are measured by means of external assessment. Many subjects contain some element of coursework assessed by teachers.

The core of the Diploma Programme model

All DP students participate in the three course elements that make up the core of the model.

Theory of knowledge (TOK) is a course that is fundamentally about critical thinking and inquiry into the process of knowing rather than about learning a specific body of knowledge. The TOK course examines the nature of knowledge and how we know what we claim to know. It does this by encouraging students to analyse knowledge claims and explore questions about the construction of knowledge. The task of TOK is to emphasize connections between areas of shared knowledge and link them to personal knowledge in such a way that an individual becomes more aware of their own perspectives and how they might differ from others.

In TOK, students explore the means of producing knowledge within the core theme of "knowledge and the knower" as well as within various optional themes (knowledge and technology, knowledge and politics, knowledge and language, knowledge and religion, and knowledge and Indigenous societies) and areas of knowledge (the arts, natural sciences, human sciences, history, and mathematics). The course also encourages students to make comparisons between different areas of knowledge and reflect on how knowledge is arrived at in the various disciplines, what the disciplines have in common, and the differences between them.

Creativity, activity, service (CAS) is at the heart of the Diploma Programme. The emphasis in CAS is on helping students to develop their own identities, in accordance with the ethical principles embodied in the IB mission statement and the IB learner profile. It involves students in a range of activities alongside their academic studies throughout the Diploma Programme. The three strands of CAS are creativity (arts, and other experiences that involve creative thinking), activity (physical exertion contributing to a healthy lifestyle) and service (an unpaid and voluntary exchange that has a learning benefit for the student). Possibly, more than any other component in the Diploma Programme, CAS contributes to the IB's mission to create a better and more peaceful world through intercultural understanding and respect.

The extended essay (EE), including the world studies EE, offers the opportunity for IB students to investigate a topic of special interest, in the form of a 4,000-word piece of independent research. The area of research undertaken is chosen from one of the students' six Diploma Programme subjects, or in the case of the interdisciplinary world studies essay, two subjects, and acquaints them with the independent research and writing skills expected at university. This leads to a major piece of formally presented, structured writing, in which ideas and findings are communicated in a reasoned and coherent manner, appropriate to the subject or subjects chosen. It is intended to promote high-level research and writing skills, intellectual discovery and creativity. An authentic learning experience it provides students with an opportunity to engage in personal research on a topic of choice, under the guidance of a supervisor.

Approaches to learning and approaches to teaching

Approaches to teaching and approaches to learning across the DP refers to deliberate strategies, skills and attitudes that permeate the teaching and learning environment. These approaches and tools, intrinsically linked with the learner profile attributes, enhance student learning and assist student preparation for the

DP assessment and beyond. The aims of approaches to learning and approaches to teaching in the DP are to:

- empower teachers as teachers of learners as well as teachers of content
- empower teachers to create clearer strategies for facilitating learning experiences in which students are more meaningfully engaged in structured inquiry and greater critical and creative thinking
- promote both the aims of individual subjects (making them more than course aspirations) and linking previously isolated knowledge (concurrency of learning)
- encourage students to develop an explicit variety of skills that will equip them to continue to be actively engaged in learning after they leave school, and to help them not only obtain university admission through better grades but also prepare for success during tertiary education and beyond
- enhance further the coherence and relevance of the students' DP experience
- allow schools to identify the distinctive nature of an IB DP education, with its blend of idealism and practicality.

The five approaches to learning skills (developing thinking skills, social skills, communication skills, self-management skills and research skills) along with the six approaches to teaching (teaching that is inquiry-based, conceptually focused, contextualized, collaborative, differentiated and informed by assessment) encompass the key values and principles that underpin IB pedagogy.

The IB mission statement and the IB learner profile

The DP aims to develop in students the knowledge, skills and attitudes they will need to fulfil the aims of the IB, as expressed in the organization's mission statement and the learner profile. Teaching and learning in the DP represent the reality in daily practice of the organization's educational philosophy.

Academic integrity

The goal of academic integrity is to make knowledge, understanding and thinking transparent. Students must also master the technical components of academic integrity, which includes learning how to correctly reference and ethically use information, opinions and artificial intelligence (AI) tools.

Such transparency needs to be taught and supported throughout the educational journey so that students understand how knowledge is constructed, as well as their own role in furthering knowledge construction and building understanding. While technical proficiency is crucial, conceptual and ethical knowledge should come first.

Recent technical advancements in AI tools have sparked some concerns in the educational community as students have the potential to use these tools to produce their assessments. In some ways this is not a new academic integrity issue for the IB. These tools can effectively produce a unique essay (or other product) for the student—this can be paralleled to a student buying an essay from the internet or having a third party (such as a parent or tutor) write it for them. As in these cases of another person creating the essay for them, teachers are well placed to identify when it is not the student's own work.

Academic integrity in learning, teaching and assessment serves to promote personal integrity, engender respect for the integrity of others and their work, and ensure that all students have an equal opportunity to demonstrate the knowledge and skills they acquire during their studies.

All coursework—including work submitted for assessment—is to be authentic, based on the student's individual and original ideas with the ideas and work of others fully acknowledged. Assessment tasks that require teachers to provide guidance to students or that require students to work collaboratively must be completed in full compliance with the detailed guidelines provided by the IB for the relevant subjects.

For further information on academic integrity in the IB and the Diploma Programme, please consult the IB publications *Academic integrity policy*, *Effective citing and referencing*, *Diploma Programme: From principles into practice* and the general regulations in: *Diploma Programme Assessment procedures*. Specific information regarding academic integrity as it pertains to external and internal assessment components of this Diploma Programme subject can be found in this guide.

Acknowledging the ideas or work of another person

Coordinators and teachers are reminded that candidates must acknowledge all sources used in work submitted for assessment. The following is intended as a clarification of this requirement.

DP candidates submit work for assessment in a variety of media that may include audiovisual material, text, graphs, images and/or data published in print or electronic sources. If a candidate uses the work or ideas of another person, the candidate must acknowledge the source using a standard style of referencing in a consistent manner. A candidate's failure to acknowledge a source will be investigated by the IB as a potential breach of regulations that may result in a penalty imposed by the IB final award committee.

The IB does not prescribe which style(s) of referencing or in-text citation should be used by candidates; this is left to the discretion of appropriate faculty/staff in the candidate's school. The wide range of subjects, response languages and the diversity of referencing styles make it impractical and restrictive to insist on particular styles. In practice, certain styles may prove most commonly used, but schools are free to choose a style that is appropriate for the subject concerned and the language in which candidates' work is written. Regardless of the reference style adopted by the school for a given subject, it is expected that the minimum information given includes: name of author, date of publication, title of source, and page numbers as applicable.

Candidates are expected to use a standard style and use it consistently so that credit is given to all sources used, including sources that have been paraphrased or summarized. When writing text candidates must clearly distinguish between their words and those of others by the use of quotation marks (or other method, such as indentation) followed by an appropriate citation that denotes an entry in the bibliography. If an electronic source is cited, the date of access must be indicated. Candidates are not expected to show faultless expertise in referencing but are expected to demonstrate that all sources have been acknowledged. Candidates must be advised that audiovisual material, text, graphs, images and/or data published in print or in electronic sources that is not their own must also attribute the source. Again, an appropriate style of referencing/citation must be used.

Learning diversity and learning support requirements

Schools must ensure that equal access arrangements and reasonable adjustments are provided to candidates with learning support requirements that are in line with the IB documents *Access and inclusion policy* and *Learning diversity and inclusion in IB programmes*.

The documents *Meeting student learning diversity in the classroom* and *The IB guide to inclusive education: a resource for whole school development* are available to support schools in the ongoing process of increasing access and engagement by removing barriers to learning.

Programme standards and practices

The programme standards and practices are a set of principles for schools to ensure quality and fidelity in the implementation of IB programmes. Teaching and learning are important markers of quality and effective practice in schools; thus the expectations teachers and learners share across all IB programmes can be found in the programme standards and practices.

The programme standards and practices provide a framework to help teachers understand their rights and responsibilities in IB World Schools as they develop learning environments and experiences for their students. The IB recognizes that in order for effective teaching to take place, teachers must be supported in their understanding, well-being, environment and resources. Teachers use the core tenets of IB philosophy and pedagogy (approaches to learning, approaches to teaching), the learner profile and international-mindedness to design learning experiences that prepare learners to fulfil the aims and objectives outlined in this guide.

To learn more about teachers' rights and responsibilities, please see the IB publication *Programme standards and practices* on the Programme Resource Centre.

Guidance on the use of artificial intelligence tools

The goal of academic integrity is to make knowledge, understanding and thinking transparent. Students must also master the technical components of academic integrity, which includes learning how to correctly reference and ethically use information, opinions and AI tools.

Such transparency needs to be taught and supported throughout the educational journey so that students understand how knowledge is constructed, as well as their own role in furthering knowledge construction and building understanding. While technical proficiency is crucial, conceptual and ethical knowledge should come first.

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The IB's *Academic integrity policy* contains extensive guidance on the use of AI tools in appendix 6. This includes the following sections.

- Teaching students about academic integrity
- The IB and AI tools
- What does the IB expect when a teacher checks the authentication box to confirm that work is the student's own?
- How should teachers guide their students when using AI tools?
- Using software to improve language and grammar
- Confidence in IB results

A poster for classrooms, *The IB and artificial intelligence (AI) tools*, has also been produced, which can be downloaded for student reference.

These resources are available in the "Cross-programme" section of the Programme Resource Centre.

The IB's public website also contains extensive guidance and resources on the subject of AI. This includes, sample AI-generated activities, an interactive feedback exercise, further reading and audio clips (English only) of advice given to the UK Parliament Science and Technology Committee on the governance of artificial intelligence.

Nature of design technology

Inquiry and problem-solving are at the heart of this subject. Diploma Programme (DP) design technology requires the use of the design process as a tool that provides the methodology used to structure the inquiry and analysis of problems, the development of feasible solutions, and the testing and evaluation of the proposed solution. In DP design technology, a solution can be defined as a model, prototype, product or system that students have developed independently.

Design, and the resultant development of new technologies, has given rise to profound changes in society: transforming how we access and process information; how we adapt our environment; how we communicate with others; how we are able to solve problems; and how we work and live.

Materials were used to provide useful and decorative artefacts long before there was an understanding of why materials had different properties that could be used for different purposes. In the modern world, the reverse is the case, and designers need to have an understanding of the possibilities offered by science to realize the full potential of what they can design in terms of new technologies, products and systems.

Competent design is within the reach of everyone. Through the practice and application of well-established design principles and methodologies, individuals can increase the likelihood that a design will be successful. These principles taken together make up what is known as the design thinking process.

Designing requires an individual to be imaginative and creative, while having a substantial knowledge base of important factors that will aid or constrain the process. Decision-making needs to be supported by adequate and appropriate research and investigation. Designers must think "out of the box" to develop innovative solutions, while thinking "in the box" to conform to requirements set by clients or research.

Both the ideas of design and the process of design can only occur in a human context. Design involves multidisciplinary teams and stakeholders with different backgrounds and traditions. It is important to understand, however, that to design is to be involved in a community of inquiry with certain common beliefs, methodologies, understandings and processes. Design is multidisciplinary and draws from many areas, including the natural and social sciences, mathematics and arts.

DP design technology aims to develop internationally minded people whose enhanced understanding of design and the technological world can facilitate our shared guardianship of the planet and create a better world.

The course focuses on analysis, design development, synthesis and evaluation. The creative tension between theory and practice is what characterizes design technology within the DP sciences group.

DP design technology achieves a high level of design literacy by enabling students to develop critical-thinking and design skills that they can apply in a practical context. While designing may take various forms, it will involve the selective application of knowledge within an ethical framework.

A well-planned design technology course enables students to develop not only practical skills but also strategies for creative and critical thinking.

The DP design technology course is engaging, accessible, inspiring and rigorous. It has the following characteristics.

The course:

- draws on a wide spectrum of knowledge
- enables and empowers innovation, exploration and the acquisition of further knowledge
- actively promotes the act of **learning by experience** through topics designed for practical exploration
- raises ethical issues in design
- is underpinned by design thinking.

Design thinking involves the ability to:

- understand users, challenge one's own assumptions, redefine complex problems and create innovative solutions that can be modelled and tested
- utilize an experimental and inquiry-based approach to problem-solving
- engage with empathy, definition, ideation, prototyping and testing
- appreciate how theoretical and practical limitations affect the extent to which problems can be solved.

During the course, students will develop a product design solution. This will involve the ability to:

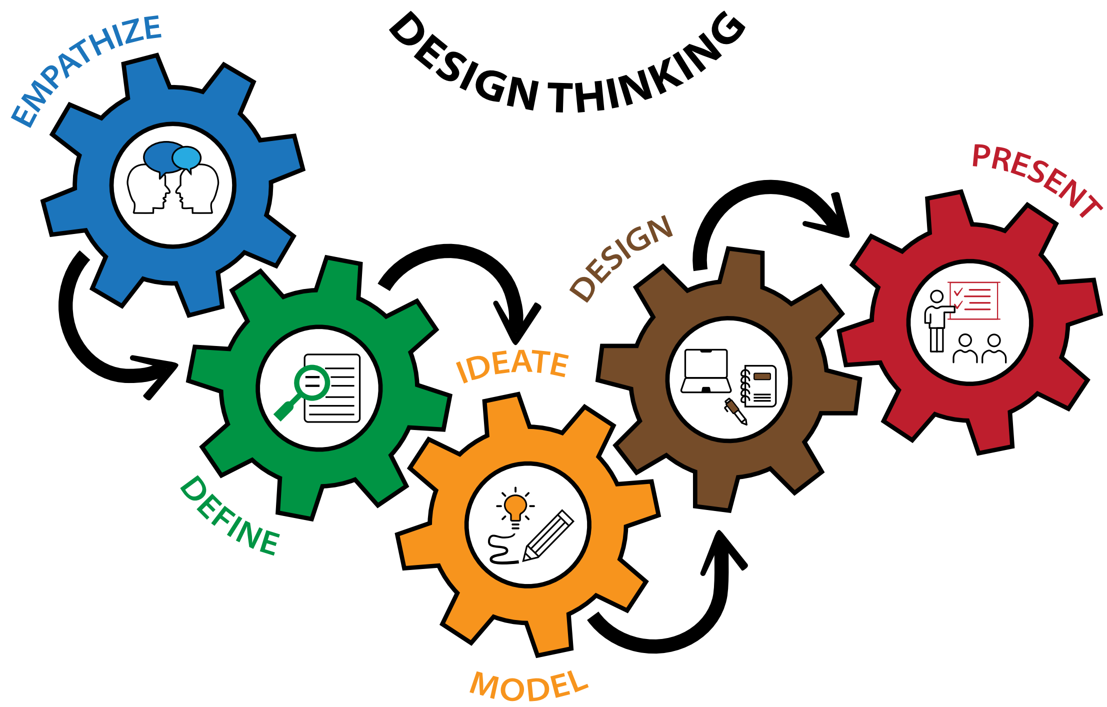
- identify a problem or need
- design, model, test and develop a product design solution (performance testing)
- liaise with clients, target audiences and end-users to evaluate the success of the product design solution (user testing).

The design thinking process

Design thinking is a problem-solving and innovation approach that places a strong emphasis on understanding the needs and perspectives of the intended users. It is a flexible and iterative process that can be applied to a wide range of challenges, from product development to service design and beyond. Design thinking typically consists of many stages, which are frequently represented as a recurring cycle. DP design technology consists of five stages of the design thinking process: empathize; defining the project; ideation and modelling; designing a solution; and presenting a solution. In the internal assessment, both standard level (SL) and higher level (HL) students follow this route (see figure 2).

Figure 2

The design thinking process in DP design technology



Empathize

- In the initial empathize stage, designers seek to understand the problem they are trying to solve from the perspective of the intended users.

- Designers engage in active listening, observation and empathy-building exercises to gain insights into the intended users' needs, motivations and pain points.
- Qualitative and quantitative research tools and research methodologies are used in this stage, including user interviews, surveys, observations and creating user personas.

Defining the project

- After gathering researched insights from the empathize stage, the focus shifts to defining the problem or challenge to be addressed.
- Designers reframe the problem in a user-centred way, ensuring that it aligns with the intended users' needs.
- The conclusion of this stage is a well-defined task analysis that serves as a guide for the subsequent stages.

Ideation and modelling

- The purpose of ideation is to generate a wide range of creative solutions to address the task analysis. There are no bad ideas during this stage, and the emphasis is on quantity and diversity of ideas.
- Prototypes are used to test and refine the ideas generated in the ideation stage.
- Modelling and prototyping techniques, such as graphical, digital or physical fidelity models, are used to communicate ideas to encourage further creativity and innovation.

Designing a solution

- Iterative cycles of prototyping and feedback refine and improve the design solution.
- Prototypes are tested with the actual intended users for the purpose of feedback and insights on their usability, desirability and effectiveness. The results of testing inform further iterations, refinements and improvements to the solutions.
- This stage may reveal new insights that can lead to a redefinition of the problem or a return to previous stages for additional ideation and prototyping.

Presenting a solution

- The intended solution should be the best version of the redesigned product, marked by thoughtful enhancements, user-centricity and a commitment to innovation.
- The final stage of the design thinking process, presenting an annotated solution with its key features, is the moment of disclosure—when the culmination of innovation, empathy and rigorous problem-solving is showcased for the intended users.
- Annotated descriptions of the key features and reasons are critical in this stage to communicate the rationale behind design decisions, the anticipated benefits of the redesigned product for the intended user(s) and support of third-party manufacturing.

Future technological developments

This subject guide is a snapshot of an ever-evolving landscape of technological advancements, and it is important to be aware that new and diverse technologies are being developed, refined and integrated into our daily lives all the time. The rapid pace of innovation means that what was considered cutting-edge today may become commonplace tomorrow.

To prepare for the future fully, students should be encouraged to stay informed about emerging technologies and be prepared to respond to examination questions that test syllabus-based knowledge within a changing technological world.

Opportunities beyond the course

DP design technology serves as a strong pathway to university, enabling students to develop both practical skills and strategies for creative and critical thinking. Possessing a strong foundation in design principles and fostering an innovative mindset are essential attributes for students aspiring to enter university programmes focused on design-related disciplines, preparing them for the academic challenges and creative demands of such pathways.

Employers highly appreciate the capacity for students to think critically and responsibly when approaching design challenges in various creative fields, including but not limited to product design, augmented reality (AR) or virtual reality (VR), fashion, architecture, interior design, interaction design, web development, 3D animation, and graphic or user interface (UI)/user experience (UX) design.

Design technology students should consider the development of a portfolio that showcases their creative and technical abilities. This will not be formally assessed but students may find the portfolio beneficial to support applications for further education or employment.

Distinction between SL and HL

While the skills and activities of design technology are common to students at both SL and HL, students at HL are required to study additional topics that are more demanding than the core materials. The distinction between SL and HL is therefore one of both breadth and depth.

Additionally, the HL course has 240 hours devoted to teaching, compared with 150 hours for the SL course.

Students at SL and HL in design technology study a common core consisting of:

- 13 core topics covering design in theory, design in practice and design in context (including the design thinking process, user-centred design (UCD), modelling and prototyping, materials, design strategies, and product analysis and evaluation)
- one piece of internally assessed work focused on the development of a solution to a problem
- the collaborative sciences project.

The HL course has 11 further topics, such as introduction to structural systems, manufacturing techniques, production systems and life-cycle analysis.

The SL course introduces students to the fundamentals of UCD, modelling, materials, design strategies and product analysis and evaluation. This provides a useful grounding in design thinking and design approaches for students who may not pursue design technology at university level.

At HL, students are required to study structural, mechanical and electronic systems, manufacturing techniques and production systems and strategies, providing a solid foundation in manufacturing for further study at university level.

Design technology and the core

Design technology and theory of knowledge

The theory of knowledge (TOK) course plays a special role in the DP by providing opportunities for students to reflect on the nature, scope and limitations of knowledge and the process of knowing through an exploration of knowledge questions.

The areas of knowledge are specific branches of knowledge, each of which can be seen to have a distinct nature, and sometimes use different methods of gaining knowledge. In TOK, students explore five compulsory areas of knowledge: history; the human sciences; the natural sciences; mathematics; and the arts.

There are several different ways in which aspects of the design technology course can be connected to the exploration of knowledge. During the learning and teaching of the design technology course, teachers and students evaluate knowledge claims by exploring questions concerning their validity, reliability, credibility and certainty, as well as individual and cultural perspectives on them.

Exploration of the relationship between knowledge and TOK concepts can help students to deepen their understanding and make connections between disciplines. For example, while discussing the circular economy's aim to eliminate waste and pollution throughout all stages of the product's life cycle, students could discuss the concepts of culture, values and responsibility. One way in which design technology teachers can help students to make these links to TOK is by drawing students' attention to knowledge questions that arise from their subject content. Knowledge questions are contestable questions about knowledge, and include questions such as the following.

- How does knowledge in design technology progress? How does that compare to how knowledge progresses in other areas of knowledge?
- Are intuitively appealing explanations more likely to be true than explanations supported by other means?
- What is the role of imagination and intuition in design technology?
- Are the methods used in design technology closer to the methods used in the arts or the methods used in the natural sciences?
- What is the relationship between facts/data and theories, and how does this differ in different areas of knowledge?
- What is the impact of culture in the production and distribution of knowledge in various areas of knowledge?
- To what extent does the methodology of an investigation limit or determine the possible outcomes?

More information on TOK can be found in the *Theory of knowledge guide*.

Design technology and the extended essay

Students who choose to write an extended essay (EE) in design technology undertake independent research as part of an in-depth study of a focused topic. The topic for study may be generated from the design technology course or may relate to a subject area beyond the syllabus content. This detailed study will help develop research, thinking, self-management and communication skills, which will support students' learning in the design technology course, and in further studies.

Examples of topics for EEs in design technology include the following.

- To what extent has the introduction of new materials to bicycle helmet design improved the survival rate of cyclists involved in car accidents?
- How can the adoption of hybrid manufacturing approaches, combining traditional and rapid prototyping methods, optimize the overall design and production process for complex 3D models?
- How likely is it that hydrogen-powered vehicles will replace electric-, petrol- and diesel-powered vehicles in the next 25 years?
- How can the amalgamation of electrical engineering principles and design technology optimize and advance robotics in manufacturing processes for increased efficiency and innovation?
- To what extent does the integration of human-centric design principles contribute to the effectiveness and user acceptance of robotic prosthetics in comparison to traditionally designed prosthetics?

It is important to recognize the differences between an EE in design technology and the design technology internal assessment component. An EE in design technology is not intended as a vehicle to demonstrate design skills; these skills are demonstrated in the design technology internal assessment.

Teachers and students are encouraged to review the *Extended essay website* and *Extended essay guide*.

Design technology and creativity, activity, service

The creativity, activity, service (CAS) component of the DP core provides many opportunities for students to link science and design concepts and topics to practical experiences. Teachers can highlight how knowledge and understanding developed through the course might inform meaningful experiences. Outside the classroom, CAS experiences might also ignite students' passion for addressing topics inside the design technology classroom.

Examples of CAS experiences with links to design technology include the following.

- Supporting community maker spaces for younger and older people to access materials, machinery, knowledge and skills to explore, create and engage with design and making activities.
- Engaging with community projects to design outdoor meeting spaces, such as parks, sports facilities and performance areas.
- Developing product design solutions with local groups to address local problems related to the United Nations Sustainable Development Goals.
- Creating a product that serves a community or social cause, such as an assistive device for individuals with disabilities.
- Designing and building scenery, props and display spaces for local arts groups or schools.

More information on CAS can be found in the *Creativity, activity, service guide*.

Design technology and international-mindedness

International-mindedness is an umbrella term through which the IB defines the goal of international education and that is exemplified by the emphasis in all IB programmes on promoting global engagement, multilingualism and intercultural understanding.

Design technology itself is an international endeavour; the exchange of information and ideas around the world has been both a cause and an effect of the development of technology. This exchange is not a new phenomenon, but it has accelerated in recent times with the development of information and communication technologies. The idea that technology is a modern invention is a myth—people began developing technologies when they first started fashioning tools from stones, making fire to process their food, and shaping material to keep themselves warm. Teachers are encouraged to emphasize this contribution in their teaching of various topics, perhaps through an analysis of the principles of early technologies and the use of timeline websites. The design technology method in its widest sense, with its emphasis on creativity, innovation, open-mindedness and freedom of thought, transcends politics, religion and nationality.

On an organizational level, many international bodies now exist to analyse and promote technology. International bodies such as the International Labour Organization, the United Nations Industrial Development Organization, the United Nations Framework Convention on Climate Change, the United Nations Conference on Trade and Development, and many others, monitor, plan and provide information about global technology benefits. The rapid profusion of these international organizations attests to the global nature of technology: both the internationalization of the design and development of technology; and the global effects of technologies, for example, climate change. Students are encouraged to access the extensive websites of these international organizations to enhance their appreciation of the international dimensions of technology.

Some topics in this guide are specifically written to bring out this global dimension. On a practical level, the collaborative sciences project mirrors real design methodology by encouraging possible collaboration between the sciences and schools across the regions.

The power of technology to transform societies is unparalleled. It has the potential to produce great universal benefits or to reinforce inequalities and cause harm to people and the environment. In line with the IB mission statement, students need to be aware of the moral responsibility of designers to ensure that appropriate technologies are available to all communities on an equitable basis and that they have the technological capacity to use this for developing sustainable societies.

The IB learner profile

The design technology course is closely linked to the IB learner profile. By following the course, students will have engaged with the attributes of the learner profile. For example, the requirements of the internal assessment component provide opportunities for students to develop every aspect of the profile. For each attribute of the learner profile, some references are given in table 1 (this list is not prescriptive or exhaustive).

Table 1

The IB learner profile

Inquirers
• Inquirers are curious; they actively use research skills, work independently and show enthusiasm about the world around them. • Teachers facilitate skill development and promote inquiry; they provide students with opportunities to ask questions, search for answers and experiment. • Learners use their inquiry skills to extend their design technology knowledge and engage with research.

Knowledgeable
• Learners explore theory, context and design issues to broaden and deepen their understanding of factual and procedural knowledge. • Access to a variety of resources and opportunities provides learner agency to develop design technology knowledge and understanding. • Learners apply their knowledge to unfamiliar contexts and make connections between concepts and facts to illustrate their understanding of UCD.

Thinkers
• Learners are eager to solve complex problems and reflect on their thinking strategies. • Teachers provide opportunities for learners to analyse their approaches and methods critically and deepen their understanding of design technology, allowing them to be creative in finding solutions to problems. • Learners practise reasoning and critical thinking by testing assumptions, formulating hypotheses, interpreting data and drawing conclusions from the evidence provided.

Communicators
• Learners collaborate effectively with others and use a variety of modes of communication to express their ideas, observations and opinions. • Teachers facilitate group work, encourage open discussions and the use of the design language to provide models for successful communication. • Learners demonstrate effective communication skills as part of collaborative activities through listening to others and sharing ideas.

Principled
• Learners take responsibility for their work, promote shared values and act in an ethical manner. • Teachers can provide opportunities to model principled behaviour, including acknowledging the work of others and citing sources. The collaborative sciences project provides opportunities for learners to take a principled stance. • Learners appreciate the importance of integrity in data collection and consider all data, even that which does not match their original hypothesis.

Open-minded
• Open-minded learners accept that different perspectives, models or hypotheses exist, and these can be used to enhance design understanding. • Teachers can provide models that were at the time supported by data or observations but through reasoning, deduction or falsification may be rejected or refined. • Learners need to be prepared to have their perspectives and ideas challenged through the study of design technology.

Caring
• Learners act to protect the environment and to improve the lives of others. • Teachers can draw attention to how daily choices have consequences by challenging learners to adopt sustainable practices in the workshop and provide support to help fellow learners. • Learners can connect curriculum content to global challenges, such as healthcare, energy supply or food production. The collaborative sciences project provides an opportunity for learners to support each other to enable their group to achieve their goal successfully.

Risk-taker
• Risk-takers seek new opportunities to develop their learning and explore new approaches to solve problems. They actively thrive on challenges. • Teachers can provide support and guidance for learners, encouraging them to explore new techniques or methods of learning. This might include scaffolds for the use of language, modelling design methodologies and the analysis of data. As learners grow in confidence, these supports can be phased out, giving them more freedom to choose their own approach.

Balanced
• Balanced learners look holistically at all aspects of their development and ensure that various tasks are given appropriate attention without focusing on one to the detriment of others. • Teachers should encourage learners to consider a balanced perspective on design technology issues without bias. • Learners need to organize their own time effectively, giving themselves sufficient time to complete all parts of their learning without negatively impacting on the emotional and social aspects of their lives.

Reflective
• Reflective learners consider why and how they achieve success and also how they could change their approach when learning is difficult. • Teachers provide opportunities for learners to review strategies, methods, techniques and approaches to problem-solving continually, to improve their conceptual understandings in design technology. Assessment criteria or checklists can help learners to consider the quality of their work in a guided way. • Learners develop skills and concepts throughout the course, networking their knowledge by continually reflecting on their understanding.

Approaches to learning and approaches to teaching

The approaches to learning framework

What are approaches to learning skills and why do we teach them?

The approaches to learning framework seeks to develop in students affective, cognitive and metacognitive skills that will support their learning processes during and beyond their IB experience. The development of approaches to learning skills is closely connected with the IB learner profile attributes and therefore helps to advance the IB mission. The skills are an integral part of IB learning and teaching that should be developed across the whole programme—it is not expected that a single course should ever address all of them.

How are they organized?

The approaches to learning framework for IB programmes consists of five general skill categories: thinking skills, communication skills, social skills, research skills and self-management skills. Each of these categories covers a broad range, as shown by the examples presented in table 2. The skill categories are closely linked and interrelated and therefore individual skills may be relevant to more than one category.

How do we teach them?

The approaches to learning skills can be learned and taught, improved with practice and developed incrementally. Table 2 below illustrates, through a number of examples, how the design technology course can support skill development. The examples shown below are not exhaustive. Teachers are encouraged to adapt them for use in their school context and collaboratively identify further examples of approaches to learning skill development.

Further information on the approaches to learning framework and strategies for their development can be found in the *Design technology teacher support material* and *Approaches to teaching and learning in the Diploma Programme*.

Table 2

Approaches to learning skills and development

Skill category	Examples of approaches to learning skill development in the classroom
Thinking skills	• Include metacognition, reflection and critical thinking. • Improving students' metacognitive awareness helps them to become more aware of the ways that they process information, find patterns, build conceptual understandings and remember key facts and ideas. • As students reflect on data gathered through their research into a particular problem situation, their understanding of a problem deepens. • This deep understanding can lead to more effective design ideas and solutions. As students analyse situations, products and make evidence-based decisions, they develop critical thinking. • Together, these thinking skills facilitate the students' development of design thinking skills—these transferable skills allow students to engage in empathy, redefinition, ideation, prototyping, testing and evaluation.

Skill category	Examples of approaches to learning skill development in the classroom
Communication skills	• These opportunities typically occur in the internal assessment component and collaborative sciences project, where students are required to engage with clients and end-users of the solution they develop. • In order to communicate effectively with clients and intended user(s), students need to translate technical concepts into general understandings. • Written and diagrammatical communication becomes important for students as they develop their design ideas, which allow them to communicate these with other designers and experts. • As students develop their ideas, it is important for them to include annotations to their sketches and drawings to be able to impart a complete understanding of the intention of the incremental design developments. • Students can communicate these ideas in both 2- and 3-dimensional drawings and models, both physically and using computer software such as computer-aided design (CAD). • Students will need to consider the use of effective annotations, sketches, perspective, part and assembly drawings, and the use of standardized conventions to increase readability and understanding of the design ideas and proposed design solutions.
Social skills	• The connection between communication skills and social skills is significant, as communication is a two-way process involving the exchange of ideas and information. • Social skills such as collaboration are important for the advancement of design technology. • As design and the development of new technologies are often an international endeavour, it requires cooperation and collaboration between geographically diverse and disparate individuals to come together as a group. • This international collaboration is epitomized by the open-source movement—the open sharing of plans and schematics of products allowing further development or customization by another designer. • Students will engage with social interaction as they work with clients and end-users to establish design requirements, review development, and test and evaluate solutions. • This face-to-face collaboration requires different skills than collaboration online or through virtual means. • Developing these social skills both online and off-line is important for all humans and not just designers.
Self-management skills	• Self-management skills are broken down into two main areas—organization skills and affective skills. • Organization skills are important for all aspects of project management work that the students will engage with as they plan and develop solutions. • The development of organization skills will ensure students can manage their tasks effectively, identify goals and manage their own time—these transferable skills will assist students when planning research and revision related to other aspects of their course. • Affective skills focus more on the personal attributes that students will develop through engaging with the syllabus and the design project.

Skill category	Examples of approaches to learning skill development in the classroom
	• Affective skill development focuses on aspects such as managing state of mind, self-motivation, building resilience, and mindfulness, each of which is influenced by the ability of students to organize themselves and their work.
Research skills	• Research skills are at the heart of inquiry-based learning and key to problem finding and problem-solving. • Students will not be able to suddenly find solutions from nothing; rather, they are expected to conduct structured and comprehensive research to understand the fundamentals of a problem and ideate possible solutions. • Design technology, and the development of solutions to worthwhile problems, typically have a human-centred process, and require a user-centred design (UCD) process. • To generate human-centred solutions, the research skills and activities focus not only on documentation and process, but also on user research such as user observation, user interviews, surveying and focus groups, depending on the nature of a particular problem.

Experimental programme

Integral to the student experience of a design technology course is the learning that takes place through design inquiry within the classroom, design space or in the field. Experimentation through a variety of forms can be used to introduce a topic, address a phenomenon or allow students to consider and examine authentic questions and curiosities.

A school's experimental programme should allow students to experience the full breadth and depth of the course, develop design technology skills and demonstrate safe, competent and methodical use of a range of tools, techniques and equipment. Students should therefore be encouraged to develop investigations to support their learning through open-ended inquiry with a focus on design workspaces, fieldwork testing, real-world relevance, modelling and continuous improvement.

Conceptual learning

Concept-based teaching and learning is encouraged across the continuum of IB programmes.

Concepts are lasting understandings that help organize and make sense of what we learn. They are constructed, modified and activated by the learner through learning experiences. Concepts do not exist in isolation but are interrelated. Conceptual understanding is always a work in progress—it is continually being developed and refined.

Conceptual understanding is therefore an outcome of a non-linear, ongoing process of evolving understandings, adapting previous understandings, identifying and dispelling misconceptions. It consists of making connections between prior and new knowledge to construct and build an awareness of this network of knowledge.

Concepts vary in their level of abstraction and universality.

- Broad, integrating concepts can be organizing ideas that are applicable in many contexts and have relevance both within and across subject areas.
- Discipline-specific concepts provide a deep understanding of specific knowledge fields (or fields of knowledge) and help to organize knowledge further, as well as reveal connections between different areas of the subject.

For example, consider the following sequence of three concepts, which shows the more specific focus of each concept.

motivations > user-centred design (UCD) > UX design

In other words, user experience (UX) design is a component in understanding users' behaviour, which in turn helps to develop an understanding of behaviours and motivation in design. The sequence could be extended further to look at concepts such as user research, persona development, prototyping, usability testing, iterative design, accessibility, user interface (UI) in the design of a solution and information architecture, all of which provide a basis for understanding UX design.

Outcomes of a concept-based approach

Fostering critical thinking, the outcome of a concept-based approach is that students are able to:

1. identify examples of a concept
2. organize, reflect on, modify and expand their network of knowledge
3. apply concepts to existing and future knowledge
4. apply their conceptual understanding as a design thinking tool for predicting outcomes, justifying conclusions and evaluating knowledge claims.

Engaging with sensitive topics

Students and teachers are encouraged to engage with exciting, stimulating and personally relevant topics and issues that may be, at times, sensitive or personally challenging. Teachers should be aware of this and provide guidance on how to engage with such topics in a responsible manner. Consideration should be given to the personal, political and spiritual values of others.

Format of the syllabus

This is the overarching theme.

This is the name of the topic.

[XX] hours total is recommended, whether for standard level (SL) or higher level (HL).

This number is linked to the glossary of terms.

Understandings are the specifics of the content required to be taught. The student should develop these understandings—and these understandings will be assessed according to the details included in the guidance below.

This guidance provides constraints in relation to what can be assessed in an examination, typically indicated using a command term.

Linking questions link to other parts of the design technology syllabus (the topic number). These questions will not be explicitly assessed in an examination setting; however, they are important indications of how topics can be linked when building interesting, engaging and meaningful units of study.

Guiding questions frame the topic—by studying the topic students will be able to answer the question(s) with increasing depth.

A. Design in theory

A1.1 Ergonomics

Guiding question

How do ergonomic considerations influence the design of a product?

Standard level (SL) and higher level (HL): 10 hours

1.1.1	**Ergonomics is the relationship and interaction between people (aspects of the human body) and the products, systems and environments they use.**
	Students must be able to describe how ergonomics is used to improve the design of a product by making a design more efficient, usable, functional, effective and safe.

Linking question

- How are user-centred research methods used to collect human factor data? (A2.1)

Design technology practical skills

The design technology course is organized as design in theory, design in practice and design in context. Design in practice focuses on the practical application of the theoretical understandings developed in design in theory topics. The design in practice topics account for approximately 35% of the syllabus at standard level (SL) and 50% at higher level (HL).

Topics included in **design in theory** will often have a corresponding topic in **design in practice**, for example:

A2.2 Prototyping techniques (theory) corresponds with B2.2 Modelling and prototyping (practice)

A3.1 Material classification and properties (theory) corresponds with B3.1 Material selection (practice)

A3.3 Introduction to mechanical systems (theory) corresponds with B3.3 Mechanical systems application and selection (practice).

The topics in **design in theory** connect the topics in **design in context** and **design in practice** to the real-world contexts.

The internal assessment component requires students to engage in practical activities to solve a problem. The practical skills and activities relate to aspects of UCD, planning, problem-solving, designing, modelling and prototyping, testing and evaluating.

Mathematical requirements

All Diploma Programme (DP) design technology students should be able to:

- perform basic arithmetic functions: addition, subtraction, multiplication and division
- measure accurately and calculate dimensions
- interpret technical drawings, reading dimensions and measurements to understand the size and scope of a product and the relationship between its parts
- solve simple algebraic equations by rearranging the equations and substituting values
- understand principles of mathematical logic
- collect and record data
- recognize patterns in data
- present and interpret data presented in various forms, including flow charts and graphs.

Planning your course

The syllabus as provided in this subject guide is not intended to be a teaching order. Instead, it provides detail of what must be covered by the end of the course, and teachers are encouraged to cross-plan with mathematics teachers in their school to identify opportunities to support students with these requirements. Teachers should develop a scheme of work that works best for their students. For example, the scheme of work could be developed to match available resources, to take students' prior learning and experience into account, or it could be developed in conjunction with other local requirements.

Topics are organized in a table in the "Syllabus content" section. The table is organized into three columns that provide different lenses through which to view the content.

A: Design in theory comprises the theoretical understandings that underpin the course.

B: Design in practice focuses on the practical application of the theory learned.

C: Design in context connects the theory and the practice to real-world contexts.

The topics are also organized into one of four rows.

1. People
2. Process
3. Product
4. Production

The topics are labelled for ease of reference according to their position within the syllabus content overview. They are first labelled by column, then row, then topic (for example, A1.1 Ergonomics is organized as column A: Design in theory; row 1: People; topic 1).

When considering possible ways to navigate the course, teachers are encouraged to plan paths through the syllabus to connect the learning and teaching of the topics.

Teachers may be tempted to do the following.

- Teach the topics by column, i.e. teach all topics under **design in theory**, then **design in practice**, then **design in context**.
    - This approach is not recommended. Planning a course in this way will require students to learn the theoretical in an abstract way, with a significant separation of time before they are able to apply the theory in a practical way. Again, there will be a significant separation of time before they can apply their learning to a real-world context—this approach is inefficient and cannot promote deep learning nor the transfer of theory to practice. It will be difficult to build an interesting, engaging and meaningful course.

- Teach the topics by row, i.e. teach all topics organized as **people**, then **process**, then **product**, then **production**.
  - This approach facilitates the sequential development of topics from theory to practice to context; it can be difficult to plan units of study that are interesting, engaging and meaningful—the approach is limited in providing opportunities for authentic links across the syllabus.

Teachers may plan to do the following.

- Teach selected topics from **design in theory** through to **design in context**, for example, topic A1.1 Ergonomics > topic B1.1 User-centred design > topic C1.1 Responsibility of the designer.
  - This approach leads to the development of units of study that focus on a particular group of topics. It facilitates opportunities for the sequential learning of the factual, procedural and conceptual knowledge, the application of that knowledge, and the linking of that knowledge to a real-world context.
- Teach using the linking questions to connect the learning and teaching of the topics, for example, C2.2 Design for a circular economy > B2.1 design process > A3.1 Material classification and properties > A2.1 User-centred research methods > A2.2 Prototyping techniques > B2.2 Modelling and prototyping.
  - This approach allows teachers to link the topics in a holistic way, facilitating the development of interesting and engaging units of study. It promotes the transfer of knowledge, skills and understandings within an exploration of a real-world context and encourages a deeper understanding of the syllabus content and requirements.

Teachers are encouraged to seek and incorporate authentic opportunities to reinforce and model application actively through the internal assessment, which enhances constructivist and experiential learning and provides a unique chance to solidify knowledge in a real-world context. Teachers enable students to bridge the gap between theoretical understanding and practical application by creating assignments and assessments that mirror practical scenarios. This approach deepens comprehension and fosters critical-thinking and problem-solving skills.

Students, when presented with tasks grounded in real-world situations, not only engage more actively with the subject matter but also develop a richer understanding of how their learning can be directly applied in various contexts. Therefore, embracing authentic applications within the internal assessment framework becomes a catalyst for holistic and meaningful learning experiences.

Samples can be found in the teacher support material (TSM).

Prior learning

Past experience shows that students will be able to study design technology at SL successfully with no background in, or previous knowledge of, design technology. Their approach to learning, characterized by the IB learner profile attributes, will be significant here.

However, for most students considering the study of design technology at HL, while there is no intention to restrict access, some previous exposure to formal design technology education is recommended. Specific topic details are not specified, but students who have undertaken the IB Middle Years Programme (MYP) or studied an equivalent national design technology qualification or a school-based design course would be prepared for an HL subject.

Teachers should also consider the mathematical knowledge, skills and understandings detailed further in this guide in the "Mathematical requirements" section.

Links to the Middle Years Programme

Students who have studied the MYP design, mathematics and sciences courses will be well prepared for DP sciences subjects. In particular, a well-designed MYP design course will facilitate the development of the factual, procedural and conceptual knowledge required to be successful in DP design technology.

The MYP design course builds on experiences of inquiry that students have gained in their time in the IB Primary Years Programme (PYP). PYP learning and teaching experiences challenge students to be curious, ask questions, and explore and interact with the environment physically, socially and intellectually to construct meaning and refine their understanding. Even when there is no design component in the PYP, the use of structured inquiry is a precursor to the problem-solving and inquiry-based approach of MYP design.

The MYP design course develops skills linked to the MYP design cycle, which provides a model of thinking and strategy used to help students investigate problems and design, plan, create and evaluate a product. Students continuing to the DP will have experienced the use of the design cycle and will have developed critical-thinking and design skills, which they will apply and extend in design technology.

As in the MYP design course, a product can be defined as a solution that students have generated independently. The DP design technology course requires students to become actively involved in, and to focus on, the whole development process, including the practical aspects of design required for physical and computer-aided modelling, building on the skills acquired during the MYP design course.

To complete the DP design technology internal assessment successfully, students are expected to design a solution to a specific problem following the DP design process. This extends the range of skills developed in MYP design.

The MYP offers a framework for learning and teaching while maintaining flexibility with curriculum content. Consequently, the course content in MYP sciences can vary greatly from one school to another. Content in DP sciences courses is more prescribed, and this is one of the main differences teachers will notice when comparing the two programmes.

A connected, conceptual curriculum where learning is inquiry-based and contextualized is the pedagogical principle that underpins both programmes and indeed the entire IB continuum (International Baccalaureate, 2019).

Conceptual learning focuses on organizing ideas and their interconnections. A conceptual approach is encouraged in IB programmes because it promotes deep learning and facilitates the construction of further knowledge. Conceptual understanding aids the application of knowledge in unfamiliar and novel contexts. This skill is reflected in the aims and assessment objectives of both MYP and DP programmes.

Broad concepts frame MYP learning and teaching with the purpose of unifying ideas across subject areas. Discipline-specific related concepts are intended to provide disciplinary depth (International Baccalaureate, 2014). Key and related concepts are not required in the DP, although some teachers may find that they wish to continue developing a curriculum around them. In DP sciences, overarching concepts are manifested in the course roadmaps and the nature of science. DP sciences seek to highlight the interconnectedness of the course understandings. The intention is to promote conceptual understanding and further the construction of students' knowledge networks.

Both MYP and DP teaching involve inquiry-based approaches that foster a high degree of student engagement, collaboration and interaction. MYP students will gain familiarity with criterion-related assessment and the use of assessment criteria, which will further support their understanding of the DP sciences internal assessment criteria.

IB programmes encourage the exploration of scientific principles in connection to local and global contexts. Doing so helps students ground abstract concepts in more concrete local and global real-world situations as well as cultivating international-mindedness (see the "Approaches to teaching" section in the *Approaches to teaching and learning in the Diploma Programme*). Teachers should therefore weave opportunities for contextualization into the curriculum. MYP sciences analyses the real-world application of science. In the DP, sciences teachers are frequently encouraged to anchor their teaching in real-world applications that are invoked throughout the course of the programme.

In addition to equipping students with scientific knowledge and skills, the MYP and DP sciences courses share similar guiding principles that seek to develop in students the learner profile attributes.

Links to the Career-related Programme

In the IB Career-related Programme (CP), students study at least two DP subjects, a core consisting of four components, and a career-related study which is determined by the local context and aligned with student needs. The CP has been designed to add value to the student's career-related studies. This provides the context for the choice of DP courses. Courses can be chosen from any group of the DP. It is also possible to study more than one course from the same group (for example, design technology and computer science).

Design technology may be a beneficial choice for CP students considering careers in, for example, the technology, manufacturing and telecommunication industries, and international business. The skills and attributes developed through the course would be highly beneficial for those vocations that are highly practical and include a high incidence of problem-solving. This includes preparation for the world of work in the trade and service industries.

Engagement with the design technology course enhances students' problem-solving skills, critical thinking and design thinking, and provides a deep understanding of how products work and are designed, all of which assist students in preparing for the future global workplace. This in turn fosters the IB learner profile attributes that are transferable to the entire CP, providing relevance and support for the student's learning.

For the CP students, DP courses can be studied at SL or HL. Schools can explore opportunities to integrate CP students with DP students.

The collaborative sciences project

The collaborative sciences project is an interdisciplinary sciences project, providing a worthwhile challenge to DP and CP students, addressing real-world problems that can be explored through the sciences. The nature of the challenge should allow students to integrate factual, procedural and conceptual knowledge developed through the study of their disciplines.

Through the identification and research of complex issues, students can develop an understanding of how interrelated systems, mechanisms and processes impact a problem. Students will then apply their collective understanding to develop solution-focused strategies that address the issue. With a critical lens, they will evaluate and reflect on the inherent complexity of solving real-world problems.

Students will develop an understanding of the extent of global interconnectedness between national, regional and local communities, which will empower them to become active and engaged citizens of the world. In addressing local and global issues, students will appreciate that the issues of today exist across national boundaries and can only be solved through collective action and international cooperation.

The collaborative sciences project supports the development of students' approaches to learning skills, including teambuilding, negotiation and leadership. It facilitates an appreciation of the environment, and the social and ethical implications of science and technology.

Full details of the requirements are in the *Collaborative sciences project guide*.

Aims

Design technology aims

The course aims to enable students to:

1. develop conceptual understanding that allows connections to be made between different areas of the subject and to other Diploma Programme (DP) sciences subjects
2. acquire and apply a body of knowledge, methods, process, tools and techniques that characterize design technology
3. develop the ability to analyse, evaluate and synthesize information and claims relating to technological systems
4. develop the ability to approach unfamiliar situations and wicked problems with creativity and resilience
5. design, model and implement solutions to local and global problems to meet the requirements of clients, users and systems
6. develop an appreciation of the possibilities and limitations of design, technology and engineering systems
7. develop the ability to evaluate the impact of products and technologies on a range of stakeholders
8. develop the ability to communicate and collaborate effectively
9. develop awareness of the ethical, environmental, economic, cultural and social impact of design technology
10. develop an understanding of the role of the designer when engaging with changing products, processes, systems and technologies.

Assessment objectives

Assessments align with the course's aims, objectives and conceptual approach; the nature of design technology and subject-specific skills are also assessed. This allows students to demonstrate learning effectively through varied tasks that are reliably and accurately marked or moderated by subject-area educators and experts.

The assessment objectives for design technology are as follows (see table 3).

1. Demonstrate knowledge of:
    a. facts, concepts, principles and terminology
    b. design methodology, techniques and technology
    c. methods of communicating and presenting ideas and technological information.
2. Understand and apply knowledge of:
    a. facts, concepts, principles and terminology
    b. design methodology, techniques and technology
    c. methods of communicating and presenting ideas and technological information.
3. Construct, analyse and evaluate:
    a. design briefs, problems, specifications and plans
    b. appropriate methods, techniques, models and products
    c. data, information and technological explanations.
4. Demonstrate the appropriate research, development, experimentation, modelling and personal skills necessary to carry out innovative, insightful, ethical and effective design activities.

Table 3

Assessment objectives

Assessment objective (AO)	Which component addresses this assessment objective?	How is the assessment objective addressed?
AO1 Demonstrate knowledge	Paper 1 Paper 2	Students respond to a range of multiple-choice, short-answer and extended-response questions.
AO2 Understand and apply knowledge	Paper 1 Paper 2	Students respond to a range of multiple-choice, short-answer and extended-response questions.
AO3 Construct, analyse and evaluate	Paper 1 Paper 2	Students respond to a range of multiple-choice, short-answer and extended-response questions.
AO4 Demonstrate the application of skills necessary to carry out insightful and ethical investigations	The internal assessment design project	Students identify, analyse, evaluate and redesign an existing product to meet the needs of an intended user(s).

Component	Approximate weighting of assessment objectives (%)	
	AO1 + AO2	AO3
Paper 1	50	50
Paper 2	50	50
Internal assessment	Covers AO1, AO2, AO3 and AO4	

Syllabus outline

Syllabus component	Recommended teaching hours	
	SL	HL
Syllabus content	**90**	**180**
A. Design in theory	33	71
B. Design in practice	44	77
C. Design in context	13	32
Experimental programme	**60**	**60**
Design project	50	50
Collaborative sciences project	10	10
Total teaching hours	**150**	**240**

The recommended teaching time is 240 hours to complete higher level (HL) courses and 150 hours to complete standard level (SL) courses as stated in the general regulations (in the *Diploma Programme Assessment procedures*).

Syllabus content

The aim of the syllabus is to integrate concepts, topic content and the nature of design technology through inquiry. Students and teachers are encouraged to personalize their approach to the syllabus according to what best fits their interests.

Overview

	A. Design in theory	B. Design in practice	C. Design in context
1. People	A1.1 Ergonomics	B1.1 User-centred design	C1.1 Responsibility of the designer C1.2 Inclusive design C1.3 Beyond usability (HL only)
2. Process	A2.1 User-centred research methods A2.2 Prototyping techniques	B2.1 The design process B2.2 Modelling and prototyping	C2.1 Design for sustainability C2.2 Design for a circular economy
3. Product	A3.1 Material classification and properties A3.2 Introduction to structural systems (HL only) A3.3 Introduction to mechanical systems (HL only) A3.4 Introduction to electronic systems (HL only)	B3.1 Material selection B3.2 Structural systems application and selection (HL only) B3.3 Mechanical systems application and selection (HL only) B3.4 Electronic systems application and selection (HL only)	C3.1 Product analysis and evaluation C3.2 Life-cycle analysis (HL only)
4. Production	A4.1 Manufacturing techniques (HL only)	B4.1 Production systems (HL only)	C4.1 Design for manufacture strategies (HL only)

A. Design in theory

A1.1 Ergonomics

Guiding question

How do ergonomic considerations influence the design of a product?

Standard level (SL) and higher level (HL): 10 hours

1.1.1	Ergonomics is the relationship and interaction between people (aspects of the human body) and the products, systems and environments they use.
Students must be able to describe how ergonomics is used to improve the design of a product by making a design more efficient, usable, functional, effective and safe.	

1.1.2	**Anthropometrics involves the measurement of human physical dimensions expressed in the percentile range. This method specifically focuses on determining and presenting the range of individuals' physical characteristics.**
Students must be able to explain and use static and dynamic anthropometric data to design for different people and be able to discuss how factors such as age, gender, ethnicity and disability affect the anthropometric data.	

1.1.3	**Percentiles aid in the selection of appropriate anthropometric data to satisfy the majority of a user population.**
Students must be able to identify where the 5th, 50th and 5th–95th percentiles are appropriate for a design scenario.	

1.1.4	**To ensure products are appropriate to a range of percentiles, designers can choose to design products to be adjustable and/or to be produced in a range of sizes.**
Students must be able to explain the reasons why designers choose adjustability and/or range of sizes for a product, and identify products that use one or both strategies.	

1.1.5	**In design, consideration must be given to work envelopes, reach, clearance, adjustability and range of sizes.**
Students must be able to explain the importance of workspace envelopes, adjustability, reach and range of sizes clearance in relation to percentiles and how they are used when designing products.	

1.1.6	**Physiology is the study of systems and biomechanics within the human body, their responses, limitations and capabilities.**
Students must be able to explain limiting aspects of user capabilities, including users' visual accuracy, colour perception, strengths, fatigue, muscle control and hearing thresholds.	

1.1.7	**Psychology is concerned with the study of the human mind and involves the study of all the human senses that may be involved in sending information to the brain.**
Students must be able to discuss how human senses (smell, sound, touch, taste and vision) are used to influence the design and development of products.	

Linking questions

- How are user-centred research methods used to collect human factor data? (A2.1)
- Which aspects of ergonomics are appropriate for user-centred design (UCD) practice? (B1.1)
- How does ergonomics affect modelling and prototyping of potential design solutions? (B2.2)
- How important is ergonomics to inform effective inclusive design? (C1.2)

A2.1 User-centred research methods

Guiding question

How do designers understand the relationship between users, the product and the environment?

Standard level (SL) and higher level (HL): 5 hours

2.1.1	Understanding the needs, wants and limitations of end-users is the key to user-centred design (UCD).
Students must be able to explain how developing empathy with users through an understanding of their needs and carrying out (behaviours) tasks in a specified environment leads to better design.	

2.1.2	UCD is a design process that pays particular attention to the needs of potential users of a product through involvement of users at all stages of the design process.
Students must be able to explain the five stages of UCD and the advantages and disadvantages of UCD when designing products that meet the requirements of a diverse range of user needs and capabilities.	

2.1.3	UCD teams are multidisciplinary and develop a deep understanding of the user, task and the environment.
Students must be able to explain how different disciplines contribute to a better understanding of target user, task and environment when designing to meet the needs of specific target users.	

2.1.4	User-centred research methods can be used to understand a user population(s).
Students must be able to explain how user-centred research methods (field research, task analysis, user observation, interviews, surveys and focus groups) can be used to discover the true nature of a user population.	

2.1.5	Design development uses persona, scenarios and population stereotypes early in the design process.
Students must be able to discuss how a primary persona, scenarios, population stereotypes and demographics can be used to guide design development, and discuss the advantages and disadvantages of using them when engaging with UCD.	

Linking questions

- How can population stereotypes, persona and scenarios be impacted by ergonomic design? (A1.1)
- How do user-centred research methods impact the UCD of products? (B1.1)
- How do user-centred research methods allow designers to consider beyond the usability of products? (A1.2)
- How does the responsibility of the designer affect the planning and execution of user-centred research methods? (C1.1)
- Which user-centred research methods can impact the effectiveness of product analysis and evaluation? (C3.1)

A2.2 Prototyping techniques

Guiding question

Why is it necessary for designers to prototype ideas as part of a design process?

Standard level (SL) and higher level (HL): 10 hours

2.2.1	There are two techniques used in iterative design and development: low fidelity and high fidelity.
Students must be able to explain the advantages and disadvantages of using low- and high-fidelity prototyping within a design process.	

2.2.2	Drawings, either manual or prepared using computer-aided design (CAD) software, are used to explore, refine and communicate ideas.
Students must be able to outline why designers use drawings to explore, refine and communicate ideas (including informal drawing techniques such as free-hand sketching and formal drawing techniques such as assembled drawing (isometric), orthographic projection and exploded drawings), the advantages and disadvantages of using informal and formal drawing processes, and understand how these techniques are used at different stages of design development.	

2.2.3	Prototypes can be developed in both physical and virtual (digital) form.
Students must be able to discuss the purpose of prototyping and how it is used in design and product development.	

2.2.4	Physical prototypes are used to test ideas and gather insights that inform the development of a product.
Students must be able to explain how and why designers use physical prototypes (including scale, aesthetics, materials, function and performance) to enhance the development towards a final product.	

2.2.5	CAD is used to create virtual prototypes to test ideas and gather insights that inform the development of a product.
Students must be able to explain how and why designers use virtual prototypes, including the use of surface and solid models, generative design, digital humans, motion capture, haptic technology, virtual reality (VR) or augmented reality (AR), and finite element analysis (FEA).	

2.2.6	Rapid prototyping is used to create physical prototypes quickly for potential users and design teams to interact with them and provide feedback to drive design development forward.
Students must be able to respond to emerging technologies and describe the advantages and disadvantages of why designers use rapid prototyping techniques, such as: stereolithography (SLA), fused deposition modelling (FDM) and selective laser sintering (SLS).	

Linking questions

- What ergonomic aspects should be considered when selecting prototyping techniques? (A1.1)
- How are concept models used to generate user feedback in a user-centred design (UCD) approach? (B1.1)
- Why are different prototyping techniques used as part of the design process? (B2.1)
- How does a good understanding of prototyping techniques help designers approach modelling and prototyping of their potential design solutions? (B2.2)
- How can prototyping techniques be used to evaluate the appropriateness of material selection? (B3.1)
- To what extent can virtual prototypes and simulations model real-world situations involving structural, mechanical and electronic systems? (B3.2, B3.3, B3.4)

A3.1 Material classification and properties

Guiding question

How do material properties and classifications aid material selection for a specified manufacturing process or product?

Standard level (SL) and higher level (HL): 8 hours

3.1.1	**Materials are classified based on their physical, chemical and mechanical properties.**
Students must be able to explain how and why materials are classified and discuss the advantages of classifying materials in terms of physical, chemical and mechanical properties.	

3.1.2	**Materials are classified according to their source or origin.**
Students must be able to discuss frame, shell, solid and combination (for example, frame and shell) structures, and how they are used in the design of products. They need to understand that materials are classified into natural and human-made, including for example timbers, polymers, metals, glass, textiles, composites, smart materials and biomaterials.	

3.1.3	**Identifying the most suitable material for a product is a complex and challenging task, involving the consideration of physical, chemical and mechanical properties and aesthetic characteristics.**
Students must be able to evaluate the physical, chemical and mechanical properties to ensure the selection of the most appropriate material for a specific purpose.	

3.1.4	**Physical properties include aspects of a material that can be measured and observed without it changing in any way.**
Students must be able to explain density, thermal expansion, thermal conductivity, melting point, electrical resistivity and electrical conductivity.	

3.1.5	**Chemical properties include aspects of a material that lead to it chemically reacting with another.**
Students must be able to explain corrosion resistance, reactivity (food safe), hygroscopy and flammability.	

3.1.6	**Mechanical properties include aspects of a material affected by the application of a force.**
Students must be able to explain tensile and compressive strength, stiffness, toughness, hardness, malleability, elasticity, plasticity and ductility.	

3.1.7	**Composites consist of two or more materials combined to enhance their properties.**
Students must be able to explain why combining materials can create composite materials more suitable for a specific purpose or context using an example.	

3.1.8	**Smart materials are materials that have one or more properties that can be significantly changed in response to changes in their environment.**
Students must be able to explain how materials can be selected to react to external stimuli, including piezoelectricity, shape memory, photochromicity, magneto-rheostatic, electro-rheostatic and thermoelectricity.	

3.1.9	**Biodegradable materials break down in the environment after disposal or at the end of their useful life.**
Students must be able to explain how biomaterials are a key part of a circular economy and can be used by designers to design out waste.	

Linking questions

- Why is a good understanding of material properties important when designing structural systems? (A3.2)
- When do the physical properties of materials restrict the ability to use certain prototyping techniques? (A2.2)
- How do the properties of a material influence the choice of manufacturing techniques for a product? (A4.1)
- How can the characteristics of a material limit the effectiveness of modelling and prototyping as designs are developed? (B2.2)
- How important is an understanding of the mechanical properties of a material when considering structural and mechanical systems, and their applications? (A3.2, A3.3, B3.2, B3.3)
- Which classifications of properties are important when developing electronic systems and their applications? (A3.4, B3.4)
- How could the continued development of biodegradable materials influence designers' ability to address aspects of design for sustainability and design for a circular economy? (C2.1, C2.2)
- Why is a thorough understanding of materials key for effective product analysis and evaluation of products? (C3.1)
- How do design decisions related to the properties of materials and components impact a product's life-cycle analysis? (C3.2)

A3.2 Introduction to structural systems (HL only)

Guiding question

How are structures present in everyday products?

Higher level (HL): 6 hours

3.2.1	Structures are ubiquitous in nature and the built environment.
Students must be able to analyse and interpret a variety of human-made and natural structures.	

3.2.2	Structures can be classified in different ways.
Students must be able to discuss frame, shell and solid structures, and how they are used in the design of products.	

3.2.3	Structures are often comprised of multiple parts.
Students must be able to identify simply supported beams, fixed beams, cantilever beams, continuously supported beams, and columns, and explain their function.	

3.2.4	Static and dynamic forces can be identified according to how they act on a structure.
Students must be able to explain how compression, tension, torsion, bending and shear forces act within a structure, and differentiate between static and dynamic forces.	

3.2.5	In structures, it is important to know how and when an object or material will stretch, bend or break.
Students must be able to describe the relationship between stress and strain on a material under stress, and be able to outline Young's Modulus, yield strength, ultimate strength and fracture in the context of a stress-strain graph.	

3.2.6	Materials with differing Young’s Modulus are chosen for specific applications.
Students must be able to compare materials with a high Young’s Modulus and those with a low Young’s Modulus in terms of how they react when placed under stress, and explain why this is important when designing structures.	

3.2.7	When forces on a structure are in equilibrium, the structure is stable.
Students must be able to describe when a structure is in equilibrium and identify the conditions where a structure will fail (not in equilibrium).	

3.2.8	The overall design of a structure can be improved by applying strengthening techniques.
Students must be able to explain how structures can be strengthened by using struts, shape, lamination and composite materials.	

3.2.9	Structures are typically designed with a safety factor (SF) in case of overloading.
Students must be able to define an SF as a ratio of a structure’s absolute strength to the allowable load, and explain why structures are designed to include an SF.	

3.2.10	Structures are typically designed to withstand higher loads than required.
Students must be able to outline what an SF of 1 means for a structure, and explain why most structures have an SF above 1.	

Linking questions

- What ergonomic considerations should designers explore when designing and creating structures within products? (A1.1)
- Which manufacturing techniques are best suited for shell and solid structures? (A4.1)
- How do designers engage in modelling and prototyping when working with different classifications of structures? (B2.2)
- Why is Young’s Modulus an important consideration when engaging with material selection? (B3.1)
- How can a deep understanding of how forces act on structures inform the application and selection of structural systems in the real world? (B3.2)
- What are the responsibilities of the designer when designing and creating safe and durable structures for products? (C1.1)
- To what extent do SFs influence the life-cycle analysis of a structure? (C3.2)

A3.3 Introduction to mechanical systems (HL only)

Guiding question

How are mechanisms present in everyday products?

Higher level (HL): 6 hours

3.3.1	There are four types of motion involved in mechanical systems.
Students must be able to identify the four basic types of mechanical motion: linear; rotary; oscillating; and reciprocating.	

3.3.2	Mechanical systems convert an input into an output.
Students must be able to describe inputs, processes and outputs in the context of mechanical systems.	

3.3.3	Mechanical systems can provide a mechanical advantage to the user.
Students must be able to outline a mechanical advantage and suggest how simple mechanical systems may improve performance in terms of function and efficiency.	

3.3.4	Mechanical systems are used to increase or decrease the speed, direction or power of a motion.
Students must be able to identify gear-driven, belt-driven, cam, lever and linkage systems.	

3.3.5	The four types of motion can be combined to create simple or complex mechanical systems.
Students must be able to explain the basic principles of mechanical motion and discuss how gears, pulleys, cams, levers and linkages can be combined to create complex mechanical systems.	

3.3.6	Gears transmit rotary motion from one gear shaft to another, and have a number of teeth.
Students must be able to identify the different types of gear systems (spur, bevel, rack and pinion, worm, ratchet and pawl, idler and compound) and their components, and outline how they are used providing examples.	

3.3.7	Belt-driven systems are driven by pulleys.
Students must be able to identify components of pulley systems, and outline how they are used providing examples.	

3.3.8	The shape of a cam dictates the type of motion.
Students must be able identify different shaped cams (pear, circular, triangular, eccentric, oval and snail) and outline how they are used providing examples.	

3.3.9	Levers comprise a beam acting on a fulcrum (pivot) and are classed based on the relative position of the fulcrum to an applied load and effort.
Students must be able to identify the three types of levers (1st class, 2nd class and 3rd class) and the position of the Load (L), Effort (E) and the Fulcrum, and outline how they are used providing examples.	

3.3.10	Linkages are used to change the direction of a movement, alter the magnitude of a force or make parts of a system move in a particular way.
Students must be able to identify parallel, reverse and bell crank linkages, and outline how they are used providing examples.	

Linking questions

- How does an understanding of mechanical systems help designers to create effective design solutions together with an understanding of structural and electronic systems? (A3.2, A3.4)
- In what ways do the principles of mechanical systems serve as integral components in the design and functionality of robotic technologies? (A3.3, B3.3)
- To what extent can mechanical systems be used when modelling and prototyping potential design solutions? (B2.2)
- Why is it critical to ensure appropriate material selection so that mechanisms operate at full functionality over a long period of time? (B3.1)
- How does a deep theoretical understanding of mechanical systems ensure designers engage with appropriate mechanical systems application and selection? (B3.3)

- How do efficient mechanical systems contribute to a design for sustainability strategy? (C2.1)
- How does efficient mechanical system design contribute to a design for a circular economy strategy? (C2.2)
- To what extent can moving mechanical parts be simplified when considering design for manufacture strategies? (C4.1)

A3.4 Introduction to electronic systems (HL only)

Guiding question

How are electronics present in everyday products?

Higher level (HL): 6 hours

3.4.1	**Electronic systems comprise of an input, process, output and feedback loop.**
Students must be able to describe an electronic system in terms of input, process, output and feedback.	

3.4.2	**Electronics are ubiquitous and designers need to consider how they can be created so that they may be used responsibly in homes, industry and society as well as improving aspects of modern-day life.**
Students must be able to identify electronic products that are safe, energy-efficient and utilize minimal energy.	

3.4.3	**Electronic systems can be either analogue or digital.**
Students must be able to distinguish between analogue and digital systems.	

3.4.4	**An analogue system uses continually changing signals such as sine waves.**
Students must be able to describe analogue systems in terms of voltage, current, resistance, frequency and power using the International System of Units (SI): ampere (A), second (s), hertz (Hz), watt (W), volt (V), ohm (Ω). Students must be able to use the following SI multipliers: p, n, μ, m, k, M, G, T.	

3.4.5	**A digital system is designed to store, process and communicate information in digital form.**
Students must be able to describe digital systems in terms of using discrete values such as binary digits and on and off signals. Students must be able to define logic gates.	

3.4.6	**Electronic systems are composed of electronic components that have a specific purpose.**
Students must be able to explain the purpose of passive electronic components, including fixed and variable resistors, capacitors, switches, relays and active components such as diodes and transistors.	

3.4.7	**Electronic systems utilize input devices to identify a change in an environment that requires a response.**
Students must be able to explain the purpose of basic analogue and digital input electronic components, including switches and sensors (including light, temperature, humidity and sound).	

3.4.8	**Processing devices translate an input into an output.**
Students must be able to compare and differentiate basic analogue and digital electronic process components, including signal conditioning (analogue) and program control (digital).	

3.4.9	**Many everyday electronic devices contain control circuits to monitor and control.**
Students must be able to describe the use of a microcontroller as a programmable integrated circuit (PIC) into which software can be loaded to carry out a range of processing tasks.	

3.4.10	**Electronic systems utilize output devices to perform a function in response to an initial stimulus.**
Students must be able to outline basic analogue and digital electronic output components. Electronic output components are restricted to motors, haptic devices, buzzers, speakers, headphones, printers, lights, plotters, relays, braille display, light-emitting diode (LED) and liquid crystal display (LCD).	

3.4.11	**Electronic systems utilize feedback to monitor an environment and respond to a stimulus if required.**
Students must be able to compare open- and closed-loop electronic systems, identify where open- and closed-loop systems are used, and explain the purpose of feedback in a closed-loop system.	

3.4.12	**An operational amplifier (op-amp) is a high-gain voltage amplifier with differential inputs and a single output. It is one of the basic building blocks of analogue circuits.**
Students must be able to describe the common applications of op-amps, such as analogue or digital signal amplifiers used to amplify signals from sensors in internet of things (IoT) home appliances.	

3.4.13	**Digital systems communicate with each other through the use of embedded systems to perform a specific task.**
Students must be able to define an embedded system, encompassing its role in augmenting everyday products' functionality, efficiency and automation.	

3.4.14	**Electronic components are combined to perform a function in an electronic circuit, which is represented in a circuit diagram.**
Students must be able to identify the symbols used in a circuit diagram for fixed and variable resistors, capacitors, switches, relays, diodes, transistors, operational amplifiers and input and output devices.	

Linking questions

- Which material properties are particularly important to consider when designing products that include electronic systems? (A3.1)
- How does the choice between analogue and digital electronic systems affect the need for mechanical systems in products? (B3.3)
- To what extent does the inclusion of electronic systems in products affect the choice of production systems? (B4.1)
- What are the main responsibilities of the designer when designing products to be part of the IoT? (C1.1)
- How do electronic systems enable designers to engage more effectively in inclusive design? (C1.2)
- To what extent does product analysis and evaluation reveal that electronic systems improve the effectiveness of products? (C3.1)
- What are the challenges for electronic products when considering design for a circular economy? (C2.2)
- How does the inclusion of electronic systems in a product affect the life-cycle analysis of that product? (C3.2)

A4.1 Manufacturing techniques (HL only)

Guiding question

Why are different manufacturing techniques used for producing different products?

Higher level (HL): 20 hours

4.1.1	**Manufacturing techniques can be organized into five categories.**
Students must be able to outline additive, subtractive (wasting), forming, joining and finishing techniques, relevant to the properties of the selected material(s).	

4.1.2	**An additive technique is the process of creating an object by constructing it one layer at a time and typically refers to 3D printing.**
Students must be aware of current and emerging 3D printing techniques to explain how components are produced using additive manufacturing techniques, including laminated object manufacture (LOM), fused deposition modelling (FDM) and stereolithography (SLA).	

4.1.3	**Rapid prototyping is the creation of an object based on a computer model developed in a 3D modelling (CAD) program.**
Students must be able to distinguish between rapid prototyping techniques used for creating initial base models, which serve as a foundation for testing and validation, as opposed to techniques used in the production of the refined products.	

4.1.4	**Additive manufacturing is used in various industries for low-volume production runs.**
Students must be able to describe additive manufacturing techniques used in manufacturing, including powder bed fusion (PBF), material extrusion, and selective laser sintering (SLS).	

4.1.5	**4D printing is an extension of 3D printing, where the physical and chemical state of a 3D printed object changes over time due to external stimuli such as pH, temperature, water and light.**
Students must be able to explain how the use of shape memory polymers can be deployed for printing 4D objects and provide examples of their potential use.	

4.1.6	**5D dimensional additive manufacturing involves the rotation of the extruder head and the print bed in order to print in five different axes.**
Students must be able to explain how 5D technology can be used to produce long-lasting and complex components in biomedical, automobile and aerospace applications.	

4.1.7	**Subtractive techniques involve removing material from an initial 3D mass to achieve a desired shape and can also be applied to 2D or flat materials to modify or change the shape.**
Students must be able to explain how components are produced using wasting manufacturing techniques, including machining (cutting, milling, turning) and abrading processes, which are applied to both 3D and 2D materials.	

4.1.8	**Forming techniques modify the shape of a material without adding or removing any materials.**
Students must be able to explain how components are produced using forming techniques, including bending, press-forming, casting, moulding (injection, extrusion, rotational, blow, vacuum) processes.	

4.1.9	Joining techniques can temporarily or permanently join two or more similar or dissimilar materials together.
Students must be able to explain how components are assembled using joining techniques, including adhering, fastening, stitching, weaving and welding processes.	

4.1.10	Finishing techniques are used to protect and enhance the surface of a component, contributing to its longevity and an overall increase in product life.
Students must be able to suggest how natural and human-made finishing techniques (such as anodizing, electro-plating, galvanizing), coatings (such as powder-coating), polishing, sealants (such as oils, wax, silicone) enhance a product's aesthetics, level of protection, durability, longevity and the ease of maintenance of natural and human-made materials.	

4.1.11	A combination of additive, subtractive, forming, joining and finishing techniques are needed to create components and products.
Students must be able to suggest why specific manufacturing techniques have been used to create a given component.	

Linking questions

- How might material properties influence the selection of manufacturing techniques? (A3.1)
- To what extent are manufacturing techniques for commercial products used for modelling and prototyping potential design solutions? (B2.2)
- To what extent are manufacturing techniques determined by material selection? (B3.1)
- How could manufacturing techniques influence the way a structural system is designed? (A3.2, B3.2)
- How can product analysis and evaluation be used to identify the manufacturing techniques used to create a product? (C3.1)
- How can the selection of a manufacturing technique affect the outcome of a life-cycle analysis on a product? (C3.2)
- Why do manufacturing strategies influence the design choice of manufacturing techniques to create a product? (C4.1)

B. Design in practice

B1.1 User-centred design

Guiding question

How does understanding user needs directly impact the design of products and services?

Standard level (SL) and higher level (HL): 4 hours

1.1.1	User-centred design (UCD) requires a plan to structure an inquiry using user-centred research methods.
Students must be able to construct a plan for a UCD process based on research questions that engage with user-centred research methods.	

1.1.2	UCD uses specific research methods to target persona populations and it develops empathy and understanding of users' demographics.
Students must be able to apply a variety of user-centred research methods (field research, user observation, interviews, questionnaires and focus groups) and analyse data to establish users'	

1.1.2	UCD uses specific research methods to target persona populations and it develops empathy and understanding of users' demographics.
characteristics, behaviours, and the wants and needs of the target population defined by their demographics.	

1.1.3	Data collected from user-centred research is used to determine personae that represent attributes of user populations.
Students must be able to create a primary persona or personae based on user-centred research to aid design development.	

1.1.4	Products can be analysed by using usability objectives to identify opportunities for improvement.
Students must be able to explain and apply five usability objectives (learnability, efficiency, memorability, errors and satisfaction) in order to evaluate a product.	

1.1.5	A task analysis is a strategy used to develop empathy and gain understanding of how users perform a task to achieve their intended goal.
Students must be able to apply task analysis techniques to break down a process into steps and identify the critical points for design improvement.	

Linking questions

- To what extent does UCD rely on a strong foundation of ergonomics? (A1.1)
- How important is a good understanding of user-centred research methods to ensure effective UCD? (A2.1)
- To what extent can the UCD process be influenced by the quality of modelling and prototyping of potential design solutions? (B2.2)
- To what extent should a UCD process focus on ensuring inclusive design? (C1.2)
- What influence can product analysis and evaluation have on the effectiveness of UCD? (C3.1).

B2.1 The design process

Guiding question

How do designers approach problem-solving?

Standard level (SL) and higher level (HL): 6 hours

2.1.1	The design process represents a design thinking model and is comprised of five sections.
Students must be able to outline each stage of the design process (empathize; defining the project; ideation and modelling; designing a solution; presenting a solution).	

2.1.2	Research is an ongoing activity throughout the design process, critical to identifying design opportunities, understanding user needs and generating feasible real-world solutions to problems.
Students must be able to distinguish between primary and secondary sources, qualitative and quantitative data and how they are used to identify design opportunities, develop an understanding of users and generate ideas for solutions to problems.	

2.1.3	Primary research involves the collection of first-hand data relevant to the design context.
Students must be able to apply primary research methods to gather first-hand data (user observations, interviews, surveys, questionnaires, focus groups, material testing and product analysis) and analyse the data to establish user requirements and design specifications, develop a persona and suggest further developments of a solution.	

2.1.4	Secondary research involves the collection of data provided by a third party and is used to support or validate primary research.
Students must be able to analyse secondary data sources (internet-based research, government data and statistics research, university research and literature search) to establish user requirements and design specifications, develop a persona and suggest further developments for a solution.	

2.1.5	When empathizing with the user, designers develop a persona used to represent a group of end-users they are solving a problem for.
Students must be able to identify issues, problems and challenges using user-centred research methods and techniques, and to identify user needs for specific user groups to understand their experience, motivations and interactions with products and environments.	

2.1.6	Designers engage in user observation, mapping the user’s journey as they carry out a task. They use a storyboard to identify the steps in the design process and design opportunities.
Students must be able to map a user’s journey using a storyboard and identify pain points within that journey that provide design opportunities.	

2.1.7	Product analysis is a tool used by designers to gain insight into the function, performance and features of an existing product.
Students must be able to analyse a range of products that either provides a solution to a problem or can inspire a solution to a problem.	

2.1.8	The first step in solving a problem is to define it.
Students must be able to explain the nature of a problem by writing a problem statement that clearly defines their design intentions.	

2.1.9	Defining clear design specifications leads to clear parameters for the development of a solution.
Students must be able to construct design specifications based on primary and secondary research that communicate the essential and desirable success criteria of the redesigned product.	

2.1.10	The ideation and modelling stage involves developing distinct ways to solve a particular problem that demonstrate different approaches to develop a solution.
Students must be able to apply ideation techniques to develop a range of diverse and appropriate ideas that address a problem statement and respond to design specifications.	

2.1.11	Iterative analyses and evaluation of design ideas lead to improved design ideas.
Students must be able to compare their ideas with the design specifications and user needs as they refine their solutions.	

2.1.12	When developing a solution, designers use an iterative model, test, refine cycle until all major design specifications and user requirements are satisfied.
Students must be able to demonstrate iterative development of a design using the model, test, refine cycle.	

2.1.13	Models, prototypes and mock-ups of solutions are created to test their effectiveness and to gather feedback for further refinement and development.
Students must be able to create feasible models of an intended solution at appropriate levels of fidelity that generate performance data when tested with end-users.	

2.1.14	The physical details of a new product need to be communicated for it to be manufactured.
Students must be able to create detailed drawings of components and assembled products that communicate dimensions, scale and assembly details.	

2.1.15	When presenting a solution, it is important to communicate clearly the need for the solution, and the key features that demonstrate how it solves a given problem.
Students must be able to create virtual representations of a solution, highlighting key usability features, and explain how it meets the design specifications and achieves the design intentions as a proposed solution or as an improvement to an existing product.	

Linking questions

- What ergonomic considerations are important to be able to engage successfully with the design process? (A1.1)
- How do design technology students ensure they engage with user-centred research methods? (A2.1)
- To what extent are the goals of the design process aligned with the goals of a user-centred design (UCD) process? (B1.1)
- To what extent does the model, test, refine cycle require full engagement with modelling and prototyping at several levels of fidelity? (B2.2)
- Which aspects of the design process require engagement with material selection? (B3.1)
- How do the requirements of the design process ensure students are addressing the responsibility of the designer? (C1.1)
- Why is product analysis and evaluation important in the design process? (C3.1)
- To what extent does the design process require the exploration of design for manufacture strategies? (C4.1)

B2.2 Modelling and prototyping

Guiding question

How do designers communicate ideas to different stakeholders?

Standard level (SL) and higher level (HL): 30 hours

2.2.1	Drawings facilitate the discussion of concepts to others for feedback or information.
Students must be able to construct and interpret 2D drawings and 3D models, including isometric, orthographic projection, assembly and exploded drawings.	

2.2.2	Physical prototypes are 3D, tangible representations of design or systems and can be developed at a range of fidelity for different users and environments.
Students must be able to construct and interpret aesthetic and functional prototypes at different levels of fidelity, including the considerations of scale, shape and space.	

2.2.3	Computer-aided design (CAD) involves the creation, development and analysis of a design outcome using computer software.
Students must be able to construct and interpret surface, solid and virtual models.	

2.2.4	Finite element analysis (FEA) is used to simulate how a part or assembly will perform under certain conditions.
Students must be able to interpret the output from FEA.	

2.2.5	The increasing effectiveness of rapid prototyping techniques enables designers to create complex physical prototypes for testing.
Students must be able to construct and interpret CAD models suitable for rapid prototyping.	

2.2.6	Prototypes are created to gather data and feedback from potential users and clients.
Students must be able to select and use appropriate drawings, physical prototypes and CAD models to gather relevant data and feedback, which can be used to analyse and develop the design iteratively.	

Linking questions

- When creating physical prototypes, which ergonomic considerations should be taken into account? (A1.1)
- To what extent are user-centred research strategies useful to gather feedback on models and prototypes of proposed design solutions? (A2.1)
- How do designers use their knowledge of prototyping techniques to ensure effective modelling and prototyping? (A2.2)
- Which aspects of material properties can be explored through modelling? (A3.1)
- How can information about a proposed structural system, such as a product housing, be gathered using CAD modelling and contribute to the development of a design solution? (A3.2, B3.2)
- How effectively can mechanical systems be mocked up and tested using modelling and prototyping? (A3.3, B3.3)
- How can effective electronic systems be modelled virtually? (A3.4, B3.4)
- How does the development of prototypes inform the choice of manufacturing techniques and production systems for a product? (A4.1, B4.1)
- How can modelling and prototyping be used to inform the development of a product following a user-centred design (UCD) strategy? (B1.1)
- To what extent is modelling and prototyping essential for inclusive design? (B2.2)
- To what extent can the same materials used for modelling and prototyping be used in the material selection of a commercial product? (B3.1)

B3.1 Material selection

Guiding question

Why is material selection crucial to designers of products?

Standard level (SL) and higher level (HL): 4 hours

3.1.1	Materials are selected for specific applications based on their properties.
Students must be able to identify appropriate materials based on their physical, chemical and mechanical properties.	

3.1.2	Materials are selected for specific applications based on their aesthetic characteristics.
Students must be able to identify appropriate materials based on texture, form and colour, which can also be enhanced by using a variety of finishing techniques.	

3.1.3	Additional factors influence the selection and application of materials in a specific context.
Students must be able identify appropriate materials based on cost, availability and sustainability.	

3.1.4	The selection of materials for a specific purpose can be justified through primary and secondary research.
Students must be able to justify their choice of materials using appropriate research methods.	

Linking questions

- Which factors of ergonomics influence the choice of a material? (A1.1)
- How can user-centred research methods influence the selection of a material? (A2.1)
- To what extent does material selection rely on the desired manufacturing techniques? (A4.1)
- How do designers prioritize material selection as part of the design process? (B2.1)
- Which aspects of material selection do designers have to consider to take a product beyond usability? (C1.3)
- How does the selection of a material influence whether a product can meet the requirements of design for sustainability or design for a circular economy? (C2.1, C2.2)
- How does the choice of design for manufacture strategies affect the requirements for material selection? (C4.1)
- To what extent are material selection and production systems interlinked? (B3.1, B4.1)

B3.2 Structural systems application and selection (HL only)

Guiding question

How can structural systems be incorporated into product design?

Higher level (HL): 8 hours

3.2.1	Structures are present in the design of everyday products.
Students must be able to analyse and model the forces acting on and within the structure of existing products and be able to suggest how existing structures can be strengthened.	

3.2.2	Young’s Modulus is the measure of stiffness of a material.
Students must be able to calculate Young’s Modulus using the formula: Young’s Modulus (E) = Tensile Stress (σ)/Tensile Strain (ε), and interpret stress-strain graphs for a given material, identifying the Young’s Modulus, yield strength, ultimate strength and fracture.	

3.2.3	Structures fail due to overloading, material choice, size and shape.
Students must be able to identify why a structure has failed, including interpreting data from finite element analysis (FEA).	

3.2.4	Forces acting on a structure or within a beam can be represented diagrammatically.
Students must be able to interpret simple force diagrams for a given structure.	

3.2.5	Safety factors (SFs) are a way to design in contingency to prevent failure from overloading a structure.
Students must be able to calculate SFs using the formula: SF = Ultimate Load (Stress)/Allowable Load (Stress); calculate maximum intended loads for given structures; and design structures with an SF.	

Linking questions

- To what extent can prototyping techniques, such as simulations of structures, be used to predict real-world performance? (A2.2)
- How does a deep understanding of stress-strain graphs influence the designer's material selection when designing products? (A3.1, B3.1)
- How is the structural system of a product influenced by the mechanical and electronic systems required for the product to function? (A3.3, A3.4, B3.3, B3.4)
- How does FEA play a role in modelling and prototyping? (B2.2)
- To what extent is the design of a structurally safe product the responsibility of the designer? (C1.1)
- What are the considerations for the designer of physical structures to ensure a positive life-cycle analysis result when designing a product? (C3.2)

B3.3 Mechanical systems application and selection (HL only)

Guiding question

How can mechanical systems be incorporated into product design?

Higher level (HL): 8 hours

3.3.1	Mechanical advantage of a system can be calculated.
Students must be able to calculate mechanical advantage in gear, pulley, belt and lever systems.	

3.3.2	Velocity ratios for gear-, pulley- and belt-driven systems can be calculated.
Students must be able to calculate velocity ratios for gear-, pulley- and belt-driven systems.	

3.3.3	Efficiency can be calculated.
Students must be able to calculate efficiency for gear- and belt-driven systems.	

3.3.4	Gear- and belt-driven systems are used to change the direction, speed, power and efficiency of a rotary motion.
Students must be able to calculate gear ratios and belt-driven system ratios considering the use of drive and driven gears, calculate the speed of rotation of a gear system at several points, including initial input and final output speed, and construct systems that use gears to increase or decrease speed and motion.	

3.3.5	Cams and followers are used to change rotary motion to reciprocating motion.
Students must be able to analyse how cam systems translate rotary motion into reciprocating motion, construct mechanical systems that use cams, and interpret diagrams that represent the use of cams in a system.	

3.3.6	Levers reduce the effort needed to exert a force and move a load.
Students must be able to analyse the Load (L), Effort (E) and Fulcrum, calculate Load (L) and Effort (E), construct mechanical systems that use levers, and interpret diagrams that represent the use of levers in a system.	

Linking questions

- What calculations of mechanical systems assist in making ergonomic decisions? (A1.1)
- Which user-centred research methods can be used to test the performance of a mechanical system? (A2.1)
- To what extent can mechanical systems replicate the movements of humans for the purpose of implementing a user-centred design (UCD) strategy? (B1.1)
- How can mechanical systems be developed at different levels of fidelity when modelling and prototyping? (B2.2)
- How does the inclusion of mechanical systems affect the choice of production systems that can be used to create a product? (B4.1)
- How does mechanical advantage enable an inclusive design strategy when designing products for elderly people and impaired people? (C1.2)
- How can mechanical systems be used to evoke an emotional response in products that go beyond usability? (C1.3)
- What do designers need to consider when including mechanical systems in the development of products that follow a design for a circular economy strategy? (C2.2)
- Which aspects of product analysis and evaluation are particularly relevant for products that include mechanical systems? (C3.1)

B3.4 Electronic systems application and selection (HL only)

Guiding question

How can electronic systems be incorporated into product design?

Higher level (HL): 10 hours

3.4.1	Electronics are present in the design of many everyday products.
Students must be able to analyse simple electronic products and circuits to identify the main component parts that enable them to perform a specific function.	

3.4.2	Design and manufacture of electronic products requires the use of specialized apparatus.
Students must be able to describe how to use basic electronic measuring apparatus, including multi-meters, on voltage, current and resistance ranges, and oscilloscopes to observe waveforms.	

3.4.3	Voltage (V) in a circuit is calculated by a combination of current (I) and resistance (R), and electrical power (P) is calculated by a combination of voltage (V) and current (I).
Students must be able to calculate power, voltage, current and resistance in a circuit, considering $V = IR$ and $P = VI$ by rearranging equations and substituting values.	

3.4.4	Resistors and capacitors can be used in series or parallel in a circuit for different purposes.
Students must be able to calculate resistance and capacitance in series and parallel in a circuit.	

3.4.5	Electronic systems are used to perform a specific function, which can be mapped using a flow diagram.
Students must be able to construct flow diagrams (using appropriate symbols) to model a programmable system that controls an electronic device.	

3.4.6	System diagrams depict the components and the arrangement of circuits.
Students must be able to construct diagrams for simple circuits that use resistors, capacitors, switches, relays, diodes, transistors, operational amplifiers, integrated circuits, and input and output devices.	

3.4.7	Digital systems at the first stage of the input–process–output model use inputs to sense changes in their environment.
Students must be able to determine the use of sensors to collect and input information into a digital system, including accelerometer (motion), ultrasonic (distance or proximity), photoresistor (light), voltage (moisture), hygrometer (humidity and air temperature), pressure (barometric), microphone (sound) and infrared (radiation or heat).	

3.4.8	Digital systems at the second stage of the input–process–output model use control circuits to monitor and control.
Students must be able to create simple circuits that use microcontrollers as a programmable integrated circuit (PIC) with appropriate software to carry out a predetermined task.	

3.4.9	Digital systems use logic to compare input data.
Students must be able to describe digital systems in terms of the binary number system, Boolean algebra, logic gates such as AND, OR and NOT, combinational logic circuits and sequential logic circuits, and be able to construct truth tables for a digital circuit.	

3.4.10	Digital systems at the third stage of the input–process–output model use the output to communicate to or control their environment.
Students must be able to determine appropriate output devices to communicate information or physically control an environment, including motors (including servos and pumps), LCD display (communication and light), buzzer (sound) and relay (mechanical).	

3.4.11	Digital systems can communicate with each other using embedded systems.
Students must be able to compare the protocol embedded systems used to communicate with other systems (Wi-Fi vs Bluetooth vs 5G).	

Linking questions

- Which ergonomic considerations need to be considered when designing products with electronic systems? (A1.1)
- What are the advantages of using virtual prototyping techniques when designing electronic systems? (A2.2)
- Which material classifications and properties are important when designing products that include electronic systems? (A3.1)

- To what extent can the usability objectives in a user-centred design (UCD) strategy be tested with products that have electronic systems? (B1.1)
- How can mechanical systems be combined with electronic systems to create products classed as convergent technologies? (B3.3, B3.4)
- How can the addition of electronic systems enhance a product using an inclusive design strategy? (C1.2)
- How do designers minimize or eliminate the adverse effects of electronic products using a design for sustainability strategy? (C2.1)
- How do designers ensure electronic materials and components are recoverable for use in a design for a circular economy strategy? (C2.2)
- To what extent do products that include electronic systems have a greater impact when subjected to a life-cycle analysis? (C3.2)
- How can design for manufacture strategies take advantage of the inclusion of electronic components? (C4.1)

B4.1 Production systems (HL only)

Guiding question

How is the ideal production system determined for a product?

Higher level (HL): 7 hours

4.1.1	**Production systems can be unique and specific to the type of product being manufactured.**
Students must be able to identify the most effective type of production system (craft, mechanized, automated, assembly line, hybrid production systems and computer integrated manufacturing (CIM)) used in the manufacture of a given product.	

4.1.2	**Production systems can be categorized based on the balance between the manufacturer and the tools and machinery they use.**
Students must be able to discuss the advantages and disadvantages of each production system, including craft production, mechanization, automation, assembly line, hybrid production systems and CIM.	

4.1.3	**Production systems are selected according to the required scale of production.**
Students must be able to determine appropriate manufacturing techniques for each scale of production, including one-off production, batch production, mass production, mass customization and continuous production.	

4.1.4	**Various factors influence the choice of manufacturing techniques.**
Students must be able to discuss factors that influence choices of manufacturing techniques, including type of product (part) being manufactured, type of material(s) used in production, scale of production, production system, cost constraints and environmental considerations. Students must be able to justify the selection of appropriate manufacturing techniques for the production of a product.	

4.1.5	**The design of a production system requires an understanding of a product, its component parts and the manufacturing techniques used.**
Students must be able to deconstruct and analyse multi-component products to determine how they were made and their relevance within the assembly and function of a product.	

4.1.6	The design of a product is influenced by the limitations of a production system and manufacturing techniques.
Students must be able to discuss how production methods can influence the function and aesthetics of a product.	

Linking questions

- To what extent are prototyping techniques becoming production systems? (A2.2)
- Which aspects of structural, mechanical and electronic systems impact on the availability of certain production systems? (A3.2, A3.3, A3.4, B3.2, B3.3, B3.4)
- How does the design of a product for specific manufacturing techniques limit the choice of production system that can be used to create it? (A4.1)
- How does material selection in a commercially viable product impact the cost of using different production systems? (B3.1)
- How do production techniques influence aspects of user-centred design (UCD) that go beyond usability? (C1.3)
- How does the scale of production impact a product when using a design for a circular economy strategy? (C2.2)
- Why is a deep understanding of how components are manufactured and assembled vital for effective product analysis and evaluation? (C3.1)
- To what extent does the selection of a production system affect the outcome of a product's life-cycle analysis? (C3.2)
- To what extent does the choice of design for manufacture strategies affect the feasibility of certain production systems? (C4.1)

C. Design in context

C1.1 Responsibility of the designer

Guiding question

What is the role of a designer in innovative and continuous product development?

Standard level (SL) and higher level (HL): 2 hours

1.1.1	A designer has a responsibility to the needs of clients, their community and the environment when designing and creating products.
Students must outline how design decisions have resulted in products that have had significant positive or negative impacts on a community or on the environment's sustainability.	

1.1.2	It is a designer's responsibility to ensure their products are safe to use.
Students must be able to discuss how standards can help designers ensure the well-being, health and safety of users when using their products.	

1.1.3	Products can become obsolete due to a number of factors and this can be planned.
Students must be able to discuss how obsolescence (including planned, social, style, functional, technological) affects the triple bottom line (TBL) and identify products that have been impacted.	

Linking questions

- How does the classification and properties of the materials affect the designer's ability to meet their responsibilities to minimize negative impacts on the communities they design for? (A3.1)
- What are the key considerations of ensuring products can be used safely when designing them to include mechanical and electronic systems? (A3.3, A3.4, B3.3, B3.4)
- To what extent are there differences between the responsibility of the designer and the responsibility of the design student as they engage with the design process? (B2.1)
- How does the designer mitigate the impact of social, style, functional and technological obsolescence when using a design for sustainability strategy? (C2.1)
- How do designers ensure they design out obsolescence when working with a design for a circular economy strategy? (C2.2)
- To what extent is it the responsibility of the designer to ensure that the outcome of the life-cycle analysis for their product is relatively positive? (C3.2)

C1.2 Inclusive design

Guiding question

How do designers design mainstream products and environments that are accessible and attractive to the largest possible number of people?

Standard level (SL) and higher level (HL): 2 hours

1.2.1	Inclusive design ensures products that address the needs of the widest possible audience, regardless of their age or ability, and focuses on designing universally acceptable products for all users.
Students must be able to discuss how inclusive design requires designing universally accessible products for all users, including those with physical, sensory and cognitive impairments.	

1.2.2	Inclusive design is not always possible.
Students must be able to discuss how the average person correlates to the 50th percentile adult and child, and how it is not always appropriate to design for the average person.	

1.2.3	Designers often use a "design for extremes" strategy to develop solutions suitable for use by those with physical, sensory and cognitive impairments, which are also appropriate for the general population.
Students must be able to discuss the advantages of designing for extremes when designing products for a general population, and identify where a design for extremes strategy has been used.	

Linking questions

- To what extent is a deep understanding of ergonomics important when engaging with inclusive design? (A1.1)
- To what extent can designers remove personal bias when using user-centred research methods? (A2.1)
- How can products integrate mechanical systems to improve accessibility and usability in an inclusive design approach? (A3.3, B3.3)
- To what extent can the inclusion of electronic systems in products enhance accessibility and usability for all end-users? (A3.4, B3.4)
- Which aspects of inclusive design benefit from the designer going beyond usability when designing products? (C1.3)
- How important is accessibility and usability when conducting product analysis and evaluation? (C3.1)

C1.3 Beyond usability (HL only)

Guiding question

How do designers go beyond accessibility and usability to address a wider range of issues to improve products and services?

Higher level (HL): 6 hours

1.3.1	**The four-pleasure framework can act as a critical component to determine how users interpret and interact with a product.**
Students must be able to outline how the four-pleasure framework can be used to create designs that intentionally trigger socio-, physio-, psycho- and ideo-pleasure responses.	

1.3.2	**The attract/converse/transact (ACT) model is a framework used by designers to improve the relationship between a user and a product.**
Students must be able to suggest how the ACT model can be used as a framework for creating products that intentionally trigger positive emotional responses, considering desirability, usability and usefulness.	

Linking questions

- Which aspects of the four-pleasure framework are heavily influenced by ergonomic considerations such as smell, sound, touch, taste, emotion and aesthetics? (A1.1)
- How can material selection be used to trigger physio- or ideo-pleasure? (B3.1)
- To what extent does the ACT model promote inclusive design? (C1.2)

C2.1 Design for sustainability

Guiding question

How can design for sustainability ensure we meet our current needs without compromising our future existence?

Standard level (SL) and higher level (HL): 2 hours

2.1.1	**Design for sustainability involves the choices and decisions made for developing designs (products) and design methodologies.**
Students must be able to discuss strategies to achieve sustainability and the importance of decision-making when addressing issues related to sustainable design, including waste, pollution and energy consumption.	

2.1.2	**The five principles of sustainable design are that a product must be cyclic (create no waste), solar (use clean energy), safe (cause no harm), efficient (use the least amount of energy and materials as possible) and social (support basic human rights) (Datchefski, 1999).**
Students must be able to analyse sustainable products to demonstrate how they meet Datchefski's principles.	

2.1.3	**The triple bottom line (TBL) measures levels of success of a product in relation to social (people), economic (profit) and environmental (planet), which are key responsibilities of a designer.**
Students must be able to explain the TBL and the relationship between the three Ps (people, profit, planet), which includes conflict and compromise.	

2.1.4	Designers make decisions by considering the balance between the three Ps of the TBL.
Students must be able to explain how the TBL can help designers to prioritize the needs of clients, communities and the environment to discover design opportunities.	

Linking questions

- What are the advantages of using virtual prototyping techniques over physical prototyping techniques when developing sustainable products? (A2.2)
- Does material classification suggest the sustainability of a material? (A3.1)
- To what extent does a user-centred design (UCD) strategy promote the development of a sustainable product? (B1.1)
- How important is material selection when creating products that are designed to be sustainable? (B3.1)
- What complications do electronic systems introduce to the sustainability of a product? (B3.4)
- Why are certain production systems considered less sustainable than others? (B4.1)
- To what extent is design for sustainability the responsibility of the designer? (C1.1)
- How does a product developed using a design for sustainability strategy tend to perform under a life-cycle analysis? (C3.2)

C2.2 Design for a circular economy

Guiding question

How do designers minimize waste and reduce product waste and pollution?

Standard level (SL) and higher level (HL): 2 hours

2.2.1	A circular economy is a closed-loop system where resources are continuously repurposed.
Students must be able to compare and contrast a linear approach and the circular economy.	

2.2.2	The aim of the circular economy is to eliminate waste and pollution throughout all stages of a product's life cycle.
Students must be able to discuss how designers can design products in ways that eliminate waste and pollution, including designing for longevity, upgradability, disassembly and dematerialization.	

2.2.3	An objective of the circular economy is to incorporate biodegradable materials.
Students must be able to discuss why biodegradable materials are a preferred material in a circular economy model.	

2.2.4	An objective of the circular economy is to recover and restore products, components and materials.
Students must be able to discuss how designers can consider the recovery and restoration of products, components and materials through take-back legislation, reuse, repair, recondition or recycling.	

2.2.5	The circular economy relies on the use of renewable energy.
Students must be able to identify renewable energy sources and discuss why the circular economy relies on the use of renewable energy.	

Linking questions

- How can high-fidelity prototyping techniques ensure a product can enter the circular economy? (A2.2)
- Which manufacturing techniques should be avoided when designing products for a circular economy? (A4.1)
- To what extent does material selection affect a product's suitability as part of a circular economy? (B3.1)
- How can modular electronic systems aid a design for a circular economy strategy? (B3.4)
- To what extent does the selection of a particular production system prevent a product from being suitable for integration into a circular economy? (B4.1)
- Why are some products that are developed using a design for sustainability strategy not suitable to be part of a circular economy? (C2.1)
- How can the suitability of a product for a circular economy be determined through product analysis and evaluation? (C3.1)
- To what extent are products designed for a circular economy likely to result in a positive outcome of a life-cycle analysis? (C3.2)
- To what extent do design for manufacture strategies promote a design for a circular economy strategy? (C4.1)

C3.1 Product analysis and evaluation

Guiding question

How does product analysis and evaluation inform various stakeholders and aid in a product's future development?

Standard level (SL) and higher level (HL): 5 hours

3.1.1	**Product analysis and evaluation is a process that involves examining a product performance to determine its strengths and weaknesses, and identify opportunities for improvement.**
Students must be able to discuss the purpose of a product analysis exercise and why it is important for product design development.	

3.1.2	**As part of the product analysis process, a product should be tested and information gathered from a range of stakeholders.**
Students must be able to identify the various stakeholders, such as users, manufacturers and engineers, that will help in any future development of a product.	

3.1.3	**A SWOT analysis is a standard product analysis tool that is used to identify a product's strengths, weaknesses, opportunities and threats.**
Students must be able to analyse a product using a SWOT analysis based on function, performance, usability, features and materials.	

3.1.4	**Function, performance and usability can be established using data generated through testing and reverse engineering.**
Students must be able to use data generated from relevant testing and/or reverse engineering to identify areas of the product that require improvement and to determine how well the product meets the needs of the user.	

3.1.5	**Weaknesses identified in a product or range of products can lead to opportunities for product improvement.**
Students must be able to compare competing and similar products to identify opportunities for further product improvements.	

3.1.6	**Constructive discontent can be used to identify areas where the product is not meeting the needs of its users and to determine how it can be improved to meet those needs.**
Students must be able to identify areas where a product is not meeting the needs of its users.	

3.1.7	**Product analysis enables designers to understand a product better.**
Students must be able to discuss the purpose of a product analysis task and why it is important for product design development.	

Linking questions

- Which aspects of ergonomics are vital to establish when analysing the usability of products? (A1.1)
- To what extent does the evaluation of products rely on user-centred research methods? (A2.1)
- How does the product analysis and evaluation of products that include mechanical and/or electronic systems differ from products without those systems? (A3.3, A3.4, B3.3, B3.4)
- Why is it important to know which manufacturing techniques were used to make a product when conducting product analysis and evaluation? (A4.1)
- To what extent is product analysis a fundamental aspect of the design process? (B2.1)
- To what extent does material selection have an impact on the success of a product? (B3.1)
- What types of information can designers gain from product analysis and evaluation in relation to production systems? (B4.1)
- Why is it the responsibility of the designer to learn from product analysis and evaluation tasks when redesigning products? (C1.1)
- What is the relationship between life-cycle analysis and product analysis? (C3.2)

C3.2 Life-cycle analysis (HL only)

Guiding question

Why should designers consider the effects a product has on the environment?

Higher level (HL): 7 hours

3.2.1	**A life-cycle analysis (also known as the five stages of life-cycle analysis) helps designers factually analyse a product's entire life cycle in terms of sustainability.**
Students must be able to explain and discuss life-cycle analysis considerations, such as global warming potential, air, water and soil pollution, ecotoxicity and resource depletion, that cause environmental impact.	

3.2.2	**Designers evaluate the environmental impacts of a product or service. In the case of a product, the environmental impact is assessed from raw material extraction and processing (cradle), through the manufacture, distribution and use, to the recycling or final disposal of the materials (grave).**
Students must be able to explain the life-cycle analysis inventory stages (cradle-to-grave) and the materials and energy usage that go into these processes: raw material extraction; manufacture; distribution and transport; use and maintenance; and disposal and recycling.	

Linking questions

- How can the selection of manufacturing techniques influence the outcomes of a life-cycle analysis? (A4.1)
- Which aspects of a life-cycle analysis are most affected by material selection? (B3.1)
- What is the impact of selecting a particular production system on a life-cycle analysis? (B4.1)
- To what extent is it the responsibility of the designer to ensure a product achieves a positive life-cycle analysis? (C1.1)
- What is the role of the life-cycle analysis in determining if a product has been developed successfully using a design for sustainability strategy? (C2.1)
- How can a life-cycle analysis help designers to make decisions when engaging with design for a circular economy? (C2.2)
- To what extent do design for manufacture strategies affect the outcomes of a life-cycle analysis? (C4.1)

C4.1 Design for manufacture strategies (HL only)

Guiding question

How can the evolution of production systems transform the way products are designed and manufactured, and transform the efficient disposal of products?

Higher level (HL): 6 hours

4.1.1	Design for manufacture (DfM) comprises of three strategies.
Students must be able to outline design for process, design for assembly and design for disassembly strategies.	

4.1.2	Design for process considers how products are made using a specific manufacturing technique.
Students must be able to outline the advantages of design for process and explain how a product could be designed using this strategy.	

4.1.3	Design for assembly considers how components of a product are combined.
Students must be able to outline the advantages of design for assembly and explain how a product could be designed using the design for assembly strategy.	

4.1.4	Design for disassembly considers how components of a product can be separated.
Students must be able to outline the advantages of design for disassembly and explain how a product could be designed using this strategy.	

4.1.5	The selection of DfM strategies has a direct effect on the environmental impact of the manufacture, use and disposal of a product.
Students must be able to discuss how designers use DfM strategies to reduce the environmental impact of the manufacture, use and disposal of products.	

Linking questions

- Why is a design for assembly strategy important when designing mechanical systems? (A3.3, B3.3)
- When using a design for process strategy, what are the key considerations for identifying appropriate manufacturing techniques for the production of a product? (A4.1)
- To what extent are DfM strategies compatible with the goals of user-centred design (UCD)? (B1.1)

- What are the advantages of using a DfM strategy when engaging with the design process? (B2.1)
- How do modelling and prototyping resolve design issues when using a DfM strategy? (B2.2)
- To what extent does material selection influence the choice of a DfM strategy? (B3.1)
- To what extent is the selection of production systems limited when using a DfM strategy? (B4.1)
- To what extent is the design for disassembly strategy important when engaging with a design for a circular economy approach? (C2.2)
- In what ways can the selection of a DfM strategy affect the outcome of a life-cycle analysis? (C3.2)

Assessment in the Diploma Programme

General

Assessment is an integral part of teaching and learning. The most important aims of assessment in the Diploma Programme (DP) are that it should support curricular goals and encourage appropriate student learning. Both external and internal assessments are used in the DP. IB examiners mark work produced for external assessment, while work produced for internal assessment is marked by teachers and externally moderated by the IB.

There are two types of assessment identified by the IB.

- **Formative assessment** informs both teaching and learning. It is concerned with providing accurate and helpful feedback to students and teachers on the kind of learning taking place and the nature of students' strengths and weaknesses in order to help develop students' understanding and capabilities. Formative assessment can also help to improve teaching quality, as it can provide information to monitor progress towards meeting the course aims and objectives.
- **Summative assessment** gives an overview of previous learning and is concerned with measuring student achievement at, or towards the end of, the course of study.
- A comprehensive assessment plan is viewed as being integral with teaching, learning and course organization. For further information, see the *IB Programme standards and practices* document.

The approach to assessment used by the IB is criterion-related, not norm-referenced. This approach to assessment judges students' work by their performance in relation to identified levels of attainment, and not in relation to the work of other students. For further information on assessment within the DP please refer to the publication *Assessment principles and practices—Quality assessments in a digital age*.

To support teachers in the planning, delivery and assessment of the DP courses, a variety of resources can be found on the Programme Resource Centre or purchased from the IB store (store.ibo.org). Additional publications such as specimen papers and markschemes, teacher support materials (TSM), subject reports and grade descriptors can also be found on the Programme Resource Centre. Past examination papers as well as markschemes can be purchased from the IB store.

Methods of assessment

The IB uses several methods to assess work produced by students.

Assessment criteria

Assessment criteria are used when the assessment task is open-ended. Each criterion concentrates on a particular skill that students are expected to demonstrate. An assessment objective describes what students should be able to do, and assessment criteria describe how well they should be able to do it. Using assessment criteria allows discrimination between different answers and encourages a variety of responses. Each criterion comprises a set of hierarchically ordered level descriptors. Each level descriptor is worth one or more marks. Each criterion is applied independently using a best-fit model. The maximum marks for each criterion may differ according to the criterion's importance. The marks awarded for each criterion are added together to give the total mark for the piece of work.

Analytic markschemes

Analytic markschemes are prepared for those examination questions that expect a particular kind of response and/or a given final answer from students. They give detailed instructions to examiners on how to break down the total mark for each question for different parts of the response.

Inclusive access arrangements

Inclusive access arrangements are available for candidates with access requirements. Standard assessment conditions may put candidates with assessment access requirements at a disadvantage by preventing them from demonstrating their attainment level. Inclusive access arrangements enable candidates to demonstrate their ability under assessment conditions that are as fair as possible.

The IB document *Access and inclusion policy* provides details on all the inclusive access arrangements available to candidates. The IB document *Learning diversity and inclusion in IB programmes: Removing barriers to learning* outlines the position of the IB with regard to candidates with diverse learning needs in the IB programmes. For candidates affected by adverse circumstances, the publication *Diploma Programme Assessment procedures* (updated annually), which includes the general regulations, provides details on access consideration.

Responsibilities of the school

The school is required to ensure that equal access arrangements and reasonable adjustments are provided to candidates with learning support requirements that are in line with the IB documents *Access and inclusion policy* and *Learning diversity and inclusion in IB programmes: Removing barriers to learning*.

Assessment outline—SL

First assessment 2027

Component	Overall weighting (%)	Approximate weighting of objectives (%)		Duration (hours)
		1 + 2	3	
Paper 1	20	50	50	1 hour
Paper 2	40	50	50	1 hour 30 minutes
Internal assessment design project	40	All objectives are tested equally		50 hours

Assessment component	Weighting (%)
External assessment (2 hours 30 minutes)	**60**
Paper 1 (1 hour) Content drawn from design in theory, design in practice and design in context. Multiple-choice questions on standard level (SL) material only. (Total 30 marks)	**20**
Paper 2 (1 hour 30 minutes) Content drawn from design in theory, design in practice and design in context. Short-answer and extended-response questions on SL material only. (Total 50 marks)	**40**
Internal assessment (50 hours)	**40**
The internal assessment consists of one task: the design project (50 hours). This component is internally assessed by the teacher and externally moderated by the IB at the end of the course. (Total 33 marks)	

Assessment outline—HL

First assessment 2027

Component	Overall weighting (%)	Approximate weighting of objectives (%)		Duration (hours)
		1 + 2	3	
Paper 1	25	50	50	1 hour 30 minutes
Paper 2	45	50	50	2 hours 30 minutes
Internal assessment design project	30	All objectives are tested equally		50 hours

Assessment component	Weighting (%)
External assessment (4 hours)	**70**
Paper 1 (1 hour 30 minutes) Content drawn from design in theory, design in practice and design in context. Multiple-choice questions on standard level (SL) and higher level (HL). (Total 40 marks)	**25**
Paper 2 (2 hours and 30 minutes) Content drawn from design in theory, design in practice and design in context. Short-answer and extended-response questions on SL and HL. (Total 80 marks)	**45**
Internal assessment (50 hours)	**30**
The internal assessment consists of one task: the design project (50 hours) This component is internally assessed by the teacher and externally moderated by the IB at the end of the course. (Total 33 marks)	

External assessment

Detailed markschemes specific to each examination papers (1 and 2) are used to assess students.

Some of the examinations are linked to the general understanding of the nature of design technology and the design thinking process.

External assessment details—SL

Paper 1

Duration: 1 hour

Weighting: 20%

Maximum mark: 30

Paper 1 focuses on syllabus content drawn from design in theory, design in practice and design in context.

The questions on paper 1 test assessment objectives 1, 2 and 3.

The use of calculators is permitted. See the *Calculators guidance for examinations booklet* on the Programme Resource Centre.

Paper 2

Duration: 1 hour 30 minutes

Weighting: 40%

Maximum mark: 50

Paper 2 focuses on syllabus content and is based on the analysis of a product. The examination paper comprises of several short-answer and extended-response questions combining standard level (SL) topics in design in theory, design in practice and design in context.

The questions on paper 2 test assessment objectives 1, 2 and 3.

The use of calculators is permitted. See the *Calculators guidance for examinations booklet* on the Programme Resource Centre.

External assessment details—HL

Paper 1

Duration: 1 hour 30 minutes

Weighting: 25%

Maximum mark: 40

Paper 1 focuses on syllabus content drawn from design in theory, design in practice and design in context.

The questions on paper 1 test assessment objectives 1, 2 and 3.

The use of calculators is permitted. See the *Calculators guidance for examinations booklet* on the Programme Resource Centre.

Paper 2

Duration: 2 hours 30 minutes

Weighting: 45%

Maximum mark: 80

Paper 2 focuses on syllabus content and is based on the analysis of a product. The examination paper comprises of several short-answer and extended-response questions combining SL and HL content in design in theory, design in practice and design in context.

The questions on paper 2 test assessment objectives 1, 2 and 3.

The use of calculators is permitted. See the *Calculators guidance for examinations booklet* on the Programme Resource Centre.

Internal assessment

Purpose of internal assessment

Internal assessment is an integral part of the course and is compulsory for both SL and HL students. It enables students to demonstrate the application of their skills and knowledge, and to pursue their personal interests, without the time limitations and other constraints that are associated with written examinations. The internal assessment should, as far as possible, be woven into normal classroom teaching and not be a separate activity conducted after a course has been taught.

The internal assessment requirements at SL and at HL are the same.

Guidance and authenticity

The design project submitted for internal assessment must be the student's own work. However, it is not the intention that students should decide upon a title or topic and be left to work on the internal assessment component without any further support from the teacher. The teacher should play an important role during both the planning stage and the period when the student is working on the internally assessed work. It is the responsibility of the teacher to ensure that students are familiar with:

- the requirements of the type of work to be internally assessed
- the assessment criteria; students must understand that the work submitted for assessment must address these criteria effectively.

Teachers and students must discuss the internally assessed work. Students should be encouraged to initiate discussions with the teacher to obtain advice and information, and students must not be penalized for seeking guidance. As part of the learning process, teachers should read and give advice to students on one draft of the work. The teacher should provide oral or written advice on how the work could be improved, but not edit the draft. The next version handed to the teacher must be the final version for submission.

It is the responsibility of teachers to ensure that all students understand the basic meaning and significance of concepts that relate to academic integrity, especially authenticity and intellectual property. Teachers must ensure that all student work for assessment is prepared according to the requirements and must explain clearly to students that the internally assessed work must be entirely their own. Where collaboration between students is permitted, it must be clear to all students what the difference is between collaboration and collusion.

All work submitted to the IB for moderation or assessment must be authenticated by a teacher and must not include any known instances of suspected or confirmed malpractice. Each student must confirm that the work is their authentic work and constitutes the final version of that work. Once a student has officially submitted the final version of the work, it cannot be retracted. The requirement to confirm the authenticity of work applies to the work of all students, not just the sample work that will be submitted to the IB for the purpose of moderation. For further details refer to the IB publication *Academic integrity policy*, *Diploma Programme: From principles into practice* and the relevant general regulations (in *Diploma Programme Assessment procedures*).

Authenticity may be checked by discussion with the student on the content of the work, and scrutiny of one or more of the following.

- The student's initial proposal
- The first draft of the written work
- The references cited
- The style of writing compared with work known to be that of the student

- The analysis of the work by a web-based plagiarism detection service such as www.turnitin.com

The same piece of work cannot be submitted to meet the requirements of both the internal assessment and the EE.

Time allocation

Internal assessment is an integral part of the design technology course, contributing 40% to the final assessment in the standard level (SL) course and 30% to the final assessment in the higher level (HL) course. This weighting should be reflected in the time that is allocated to teaching the knowledge, skills and understanding required to undertake the work, as well as the total time allocated to carry out the work.

It is recommended that 50 hours of teaching time should be allocated to the work. This should include:

- time for the teacher to explain to students the requirements of the internal assessment
- class time for students to work on the internal assessment component and ask questions
- time for consultation between the teacher and each student
- time to review and monitor progress, and to check authenticity.

Safety requirements and recommendations

It is the responsibility of everyone involved in science education to make an ongoing commitment to safe and healthy practical work.

The working practices and protocols should be effective in safeguarding students and protecting the environment. Schools are responsible for following national or local guidelines, which differ from country to country.

Teachers and students should discuss issues relating to the design of the redesigned product, the collection of data and consultations with others. Students should be encouraged to initiate discussions with the teacher to obtain advice and information that encourages appropriate lines of independent inquiry to support the student in developing their product. Students will not be penalized for seeking advice.

Using assessment criteria for internal assessment

For internal assessment, a number of assessment criteria have been identified. Each assessment criterion has level descriptors describing specific achievement levels, together with an appropriate range of marks. The level descriptors concentrate on positive achievement, although for the lower grade boundaries failure to achieve may be included in the description.

Teachers must judge the internally assessed work at SL and at HL against the criteria using the level descriptors.

- The same assessment criteria are provided for SL and HL.
- The aim is to find, for each criterion, the descriptor that conveys most accurately the level attained by the student, using the best-fit model. A best-fit approach means that compensation should be made when a piece of work matches different aspects of a criterion at different levels. The mark awarded should be one that most fairly reflects the balance of achievement against the criterion. It is not necessary for every single aspect of a level descriptor to be met for that mark to be awarded.
- When assessing a student's work, teachers should read the level descriptors for each criterion until they reach a descriptor that most appropriately describes the level of the work being assessed. If a piece of work seems to fall between two descriptors, both descriptors should be read again and the one that more appropriately describes the student's work should be chosen.
- Where there are two or more marks available within a level, teachers should award the upper marks if the student's work demonstrates the qualities described to a greater extent; as the work may be close to achieving marks in the level above. Teachers should award the lower marks if the student's work demonstrates the qualities described to a lesser extent; the work may be close to achieving marks in the level below.

- Only whole numbers should be recorded; partial marks (fractions and decimals) are not acceptable.
- Teachers should not think in terms of a pass or fail boundary, but should concentrate on identifying the appropriate descriptor for each assessment criterion.
- The highest level descriptors do not imply faultless performance but should be achievable by a student. Teachers should not hesitate to use the extremes if they are appropriate descriptions of the work being assessed.
- A student who attains a high achievement level in relation to one criterion will not necessarily attain high achievement levels in relation to the other criteria. Similarly, a student who attains a low achievement level for one criterion will not necessarily attain low achievement levels for the other criteria. Teachers should not assume that the overall assessment of the students will produce any particular distribution of marks.
- It is strongly recommended that the assessment criteria be made available to students.

Practical work and internal assessment

The internal assessment component is the design project, which will be completed in approximately 50 hours and accounts for 40% of the final grade at SL and 30% at HL.

Student work is internally assessed by the teacher and externally moderated by the IB. The performance of the internal assessment at both SL and HL is marked against five common assessment criteria.

The internal assessment requirements and expectations at SL and HL for the five common assessment criteria are the same.

For each assessment criterion, clarifications are provided along with additional details on what is required for each strand of the criterion, including the scope, maximum word count and recommended page numbers. These parameters should be made clear to the students, and teachers must not award any marks for work that is over the word or page limit. If selected in the sample for moderation, the examiner will stop reading the report once these limits have been reached.

Teachers must ensure the internal assessment complies with the following before it is submitted.

- The internal assessment should comprise a maximum of 35 A4 pages and no more than 3,500 words (excluding annotations).
- A front cover, contents pages and appendices are not required. Examiners will not read them or consider any information contained within them.
- A4 portrait layout must be used throughout the design project with exception of the detailed dimension drawings in criterion D.
- Each annotation must not be more than 10 words. Informative annotations state schematical details only and do not describe a process or methodology of making the product. Annotations that are longer than 10 words will be considered as descriptive and therefore part of the word count.
- Annotations must be legible, preferably typed. Handwritten annotations must be clear and equivalent to Arial font size 11 pt. They should feature alongside the developmental drawings or sketches to aid the communication of ideas in support of sketches and drawings of modelling development. To ensure clarity when scanned, black ink is strongly recommended.

The design project offers ample opportunities to explore a diverse array of products using the different paradigms within the scope of design technology. Design thinking approaches are applied to a user-centred perspective in the development of a product from various domains, such as product design, fashion design or textiles, electronic product design, and others. By adopting a user-centred approach, students can place the needs, preferences and experiences of the end-users at the forefront of their design project.

The design project should demonstrate a level of complexity that aligns with the expectations of a Diploma Programme (DP) course.

It is important to note that the selected product being redesigned should correspond to the complexity and appropriateness of the project. It is unlikely for a student to achieve higher bands on the assessment criteria by attempting to redesign a simple problem with an overly complex solution.

Further clarification and examples of appropriately complex problems can be found in the *Design technology teacher support material* (TSM).

Internal assessment details—SL and HL

The design project

Duration: 50 hours

The internal assessment requirement for design technology is the same for SL and HL. It is worth 40% of the final assessment for SL and 30% of the final assessment for HL, and consists of one task—the design project.

The design project is an open-ended task in which a student must identify, analyse, evaluate and redesign an existing product to meet the needs of an intended user(s). As part of the project, students need to develop a physical fidelity model for testing and evaluation purposes.

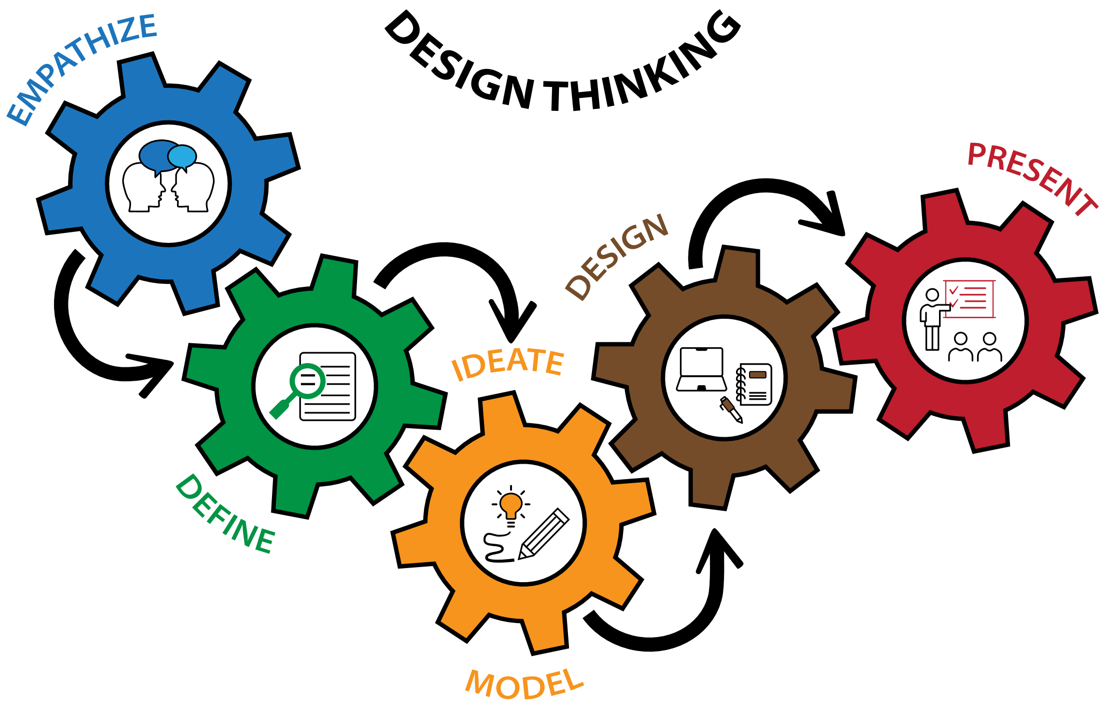
To complete the design project, students must employ the design thinking process, an iterative, non-linear problem-solving approach that places a strong emphasis on empathy, collaboration and iterative prototyping to address user problems (see figure 3, which shows the design thinking process). This method encourages students to revisit and repeat stages as needed, fostering flexibility and responsiveness to new insights or changes in project requirements. The iterative nature of the process enables continual refinement and improvement of the intended solution.

Subject-specific vocabulary is crucial to provide clarity and accuracy to the students' written material and its use is rewarded across all of the assessment criteria.

Further guidance on the design project can be found in the TSM.

Figure 3

The design thinking process in DP design technology



Students should understand the following key terms.

Annotations	The provision of additional information to support informal visual communication in the form of developmental sketches, intended to aid in indicating and highlighting key features. Informative annotations state schematical details only and do not describe a process or methodology of making the product. They feature alongside the developmental drawings or sketches to aid the communication of ideas in support of sketches and drawings of modelling development. Please note that for assessment, annotations must be legible, preferably typed. Handwritten annotations must be clear and equivalent to Arial font size 11 pt. To ensure clarity when scanned, black ink is strongly recommended. Annotations must not be more than 10 words each. Any annotation more than 10 words will be considered as counting towards the word count.
Appendices (to the design project)	Material placed in appendices provides evidence that students have conducted background research, collected and analysed raw data, and conducted tests for evaluation. **Any information critical to the assessment of the task must be in the body of the report and not in the appendix.** The appendices are not considered when marking or moderating. An examiner will not consider any of the appendices in their assessment of the work.
Primary persona	A profile of the user for a product. The persona provides a human face and story to a particular audience, making it easier to empathize and respond to the user's needs effectively.
Qualitative research	A methodological approach used to explore and understand human behaviour, experiences, perceptions and social phenomena. Qualitative research methods include interviews, focus groups, participant observation, content analysis and open-ended surveys. The data collected in qualitative research is often non-numerical and is analysed through interpretative and subjective means to identify needs, opportunities, desires, patterns, themes and relationships.
Qualitative data	This refers to non-numerical information that captures aspects such as opinions, feelings, perceptions, behaviours and attributes. Qualitative data is usually captured through interviews, observations, focus groups or open-ended survey questions.
Quantitative data	This focuses on numerical data and statistical analysis, and involves the collection of numerical data through surveys, experiments, observations or the study of existing datasets. The data is then analysed to identify needs, opportunities, desires, patterns, relationships and trends. This approach aims to draw generalizable conclusions and make predictions based on the numerical evidence.
Quantitative research	This is a systematic approach used to collect, analyse, and interpret numerical data to understand phenomena, relationships or patterns. It focuses on quantifying variables and measuring their relationships through statistical analysis. Quantitative research provides valuable insights into numerical trends, relationships and patterns, contributing to evidence-based decision-making and scientific knowledge.
Redesign	The process of modifying or the improvement of an existing solution. A redesign could involve improving and/or adapting the design, functionality, aesthetics or other aspects to enhance performance, usability and efficiency that addresses the user's or users' evolving conditions and demands.
Task analysis	A strategy used to develop empathy and understanding of how users perform a task to achieve their intended goal.

Features of the design project

Empathize

Empathy is a fundamental concept in the design process. It leads to design thinking, user-centred design (UCD) and plays a crucial role in creating products or solutions that meet the needs of the intended user(s).

The primary persona and intended user profile

The student must research the primary persona's characteristics, context, preferences, motivations and requirements to gain insights into their needs.

This research should include but is not limited to:

- demographic considerations such as age, education, ethnicity, access challenges, family status, and occupation
- abilities and skills
- behaviour patterns and attitudes
- goals, concerns, needs and opportunities
- the primary persona's physical, social and technological environment.

The individual or group directly using a product and serving as the ultimate consumers or service users of the solution is an intended user, and may also be categorized as a primary persona.

In the identifying and redesign of an existing product, the student should thoroughly understand the needs and experiences of the intended user(s). This involves undertaking qualitative and quantitative research into their needs, motivations, behaviours and experiences to empathize with them and the existing product on which they depend in order to fulfil a specific task analysis.

To do this, a student may:

- conduct interviews
- distribute surveys
- make observations
- use other appropriate research approaches or methodologies.

The storyboard

Storyboards are created as a result of the student's qualitative and quantitative research into the primary persona or intended user(s). They are used to communicate visually the sequential stages of the intended user(s) completing a task analysis with an identified product and the challenges they encounter. A storyboard can help students map out opportunities to redesign a product to provide a solution.

Existing products

Students should conduct functional analysis of existing, similar products. In cases where a product is not available for testing and analysis, a digital product may be used, excluding the user interface (UI) and user experience (UX). This analysis enables students to scrutinize what makes existing product designs a success or failure.

A student may make a comparative model that includes:

- the success of a range of products' form and functionality
- materials and components
- aesthetics and ergonomic features
- manufacturing and construction techniques
- environmental and safety considerations.

Defining the project

This stage of the design process focuses on problem-solving and innovation. Based on research and analysis generated in the empathize phase, students synthesize user-centred solutions.

The problem statement

Students should produce a concise problem statement that sets the direction of the design project intentions. The problem statement should incorporate the intended persona's user needs for the chosen product and students should be open to refining the problem statement based on new insights, feedback and challenges.

A student may:

- synthesize quantitative and qualitative research data findings
- present the context of the problem
- define the user needs and impact.

This list is not prescriptive or exhaustive.

The design specification

A design specification is generated from research data through a comprehensive investigation of the design opportunity and through the formulation of the problem statement. Students should prioritize the design’s essential and desirable specifications, and these should be justified with references to sources.

Specifications capture all crucial requirements, ensuring that the redesigned product meets the defined success criteria.

The design specification for the solution must include UX derived from product analysis and the empathize phase. Additionally, it should encompass aspects of the design dependent on their suitability for the product and their design context. The following should be considered as part of the design specification process.

- Attributes: Desired qualities or characteristics
- Components: Individual parts or elements
- Constraints: Limitations or restrictions
- Environment: Context or surroundings
- Functions: Intended operations or actions
- User needs: Specific functionality, usability and performance requirements
- Safety: Avoiding potential hazards, harm or injury, and legal requirements
- Aesthetics: Visual appeal, colour, shape, texture and style
- Manufacture requirements: Material selection, production techniques and assembly requirements

This list is not prescriptive or exhaustive.

By considering these aspects, students gain a comprehensive understanding of the design problem and develop effective solutions that meet the needs of the intended user(s).

Ideation and modelling

Students are required to generate a diverse set of feasible ideas (ideation) that ultimately arrive at a design solution (modelling). After establishing the design opportunity, primary persona, problem statement and design specifications, students engage in ideation and modelling to explore a range of potential solutions.

Ideation

Students should use appropriate informal or formal sketches or drawings and digital or physical fidelity modelling to communicate their ideas visually. As the ideas are developed and refined, their feasibility is determined against the design specifications, which help determine the appropriate aspects of each idea.

The process of sketching or drawing design ideas involves an informal or formal approach that must address the key opportunities identified through the exploration of the persona and the task analysis. Performance requirements should also be addressed as part of the design specification.

Modelling

The models created by students should be at appropriate levels of fidelity accuracy. Low-fidelity models are used to test general principles of an idea. Highly accurate fidelity models mimic the real product and are tested as they would be used by the target intended user(s).

Selecting the most appropriate idea should be validated against the performance and user requirements. To determine feasibility, the ideas are evaluated and tested based on the design specifications and feedback from intended user(s). This evaluation helps identify the most suitable idea that should be further developed in the next stage of the design process.

Designing a solution

In the design of a solution, students respond to their problem statement to create, test and refine a fidelity model of their final proposal. This should capture the essential features of the proposed redesigned solution.

Modelling a solution

Once the fidelity model ideas have been evaluated and their strengths and weaknesses identified, students are required to develop and refine the intended solution that meets the design specification requirements. This process involves iterative graphical, physical and/or digital modelling to refine the solution to meet the design specifications successfully.

Students should employ a range of modelling and testing strategies to develop and refine their idea, ensuring the product meets the design specification requirements and intended users' needs. Low-fidelity models serve as proof of concept and may test only single or few aspects.

In contrast, high-fidelity models can be tested against multiple aspects of the design specifications, offering a more comprehensive evaluation of the selected idea with end-user feedback to aid the development stages towards a solution.

The student is expected to repeat multiple model, test, refine cycles to arrive at a solution that addresses the initial design problem, design brief and specifications.

Display drawings

Formal design drawings should be produced to represent the design solution. These should include assembled, exploded and orthographic details, including components, intended to communicate the drawings accurately to a third-party manufacturer.

This process enables students to visualize and assess the feasibility of their proposed solution to their intended user(s) while encouraging a hands-on, practical approach to design. It fosters a deeper understanding of the complexities and nuances involved in translating a concept into a real-world, functional solution.

Presenting a solution

Presenting an annotated solution and its key features is the final stage of the design process. The solution reached should be the best version of the redesigned product with appropriate enhancements.

The presentation of the intended solution

The student is required to present the intended solution as though to a third-party manufacturer using appropriate visual communication methods, which can be created by hand or by computer-aided design (CAD). The presentation should showcase the product's features and may include perspective, exploded, assembly, orthographic, net development, cutaway views and finite element analysis (FEA), etc.

The student may choose how to present their redesigned product. The presentation can be digital, slide show, verbal, online or whatever suits the student's context. It can include a range of presentation styles featuring concise annotations to highlight different key features of the redesigned product and provide multiple perspectives of the student's solution.

The "Clarifications for presenting a solution" section of criterion E details the evidence required for assessment. The presentation itself (style of delivery, medium used) is not formally assessed. The student should decide who the appropriate members of the audience should be. It could be just the teacher, peers or members of the wider community.

As part of the presentation, students should highlight the annotated key features of the redesigned product. These could include, for example, aesthetics, form, functionality, dimensions, components, materials, manufacturing processes, user experience and other relevant aspects.

Comparing the redesigned solution with the existing product

The student should demonstrate:

- how the solution is an improvement on the existing product
- how the solution is intended to be used by the user(s)
- how the solution is better suited to the needs of the intended user(s).

Internal assessment criteria—SL and HL

A summary of the approximate page count and recommended word count is provided in table 4. These details are also given in the "Clarifications" section at the end of each criterion. The word count is a recommendation only, not a target. Students and teachers have the flexibility to allocate the word count based on assessment needs.

It should be noted that:

- guidance and examples to help students complete their internal assessment are provided in the TSM
- criteria should be applied in combination with the clarifications provided underneath each criterion.

Table 4

Summary of grade marks, approximate page and word count

	Grade marks	Approximate page count	Recommended word count
Criterion A: Empathize	9	9	900
Criterion B: Defining the project	6	4	1,200
Criterion C: Ideation and modelling	6	8	900
Criterion D: Designing a solution	6	10	300
Criterion E: Presenting a solution	6	4	200
Total	**33**	**35**	**3,500**

Referencing and academic integrity

Appropriate referencing to sourced information used in the report of the design project is expected. Omitted or improper referencing will be considered to be academic malpractice.

Students must ensure their assessment work adheres to the IB's academic integrity policy and that all sources are appropriately referenced and presented on the page as a footnote. Footnote references do not count towards the word count. No additional references page is required.

A student's failure to acknowledge a source appropriately will be investigated by the IB as a potential breach of regulations that may result in a penalty imposed by the IB Final Award Committee. See the "Academic integrity" section of this guide for full details.

Criterion A: Empathize

This criterion assesses the student's ability to:

- analyse a primary persona appropriate to the redesign of the product
- present a storyboard based on the observations of a primary persona using a product for a specific task
- analyse existing products and the successes and weaknesses of key features.

Mark	Strand
0	The work does not reach a standard described by the descriptors below.

Mark	Strand
1–3	The student: • states a primary persona appropriate to the redesign of the product • presents a storyboard based on a limited task analysis of the primary persona using a product for a specific task • outlines a limited range of existing products and a list of their key features.
4–6	The student: • describes a primary persona appropriate to the redesign of the product • presents a satisfactory storyboard based on a task analysis of the primary persona using a product for a specific task • describes a range of existing products identifying the successes and weaknesses of some key features.
7–9	The student: • explains a primary persona appropriate to the redesign of the product • presents a detailed storyboard based on a comprehensive task analysis of the primary persona using a product for a specific task • evaluates a range of existing products accurately identifying the successes and weaknesses of all key features.

Clarifications for empathize
Analyses the primary persona The required evidence for this strand is: • a range of digital images of the primary persona displaying their issues with an existing product • an explanation of the characteristics, context, preferences, motivations and requirements of the primary persona. The evidence for achievement against this strand should be presented in approximately two A4 pages or the equivalent.
Presents a storyboard The required evidence for this strand is: • a storyboard for the chosen primary persona that highlights the issues of using a product. Note that: • extended writing to address this strand should not be included. The evidence for achievement against this strand should be presented in approximately three A4 pages or the equivalent.
Analyses a range of existing products The required evidence for this strand is: • annotated images (see “Features of the design project” section) of the product testing. A typical range should be between four to six products. The evidence for achievement against this strand should be presented in approximately four A4 pages or the equivalent.

Criterion B: Defining the project

This criterion assesses the student’s ability to:

- produce a problem statement that identifies opportunities for the redesign of the product through the task analysis
- produce product design specifications with reference to research (UI and UX derived from existing product analysis in the empathize phase).

Mark	Strand
0	The work does not reach a standard described by the descriptors below.
1–2	The student: • presents a problem statement with limited opportunities for the redesign of the product. The links to the task analysis are superficial • provides design specifications that state the requirements for the product with limited reference to the research.
3–4	The student: • describes a problem statement with some opportunities for the redesign of the product informed through the task analysis • provides design specifications that outline the requirements for the product with relevant reference to the research.
5–6	The student: • explains a problem statement with key opportunities for the redesign of the product informed through the task analysis • provides design specifications that explain the requirements for the product with relevant and detailed reference to the research.

Clarifications for defining the project
Produce a problem statement The required evidence for this strand is: • a problem statement, which includes: ◦ the current situation ◦ the current problem ◦ a summary of research that informs the appropriateness of the problem. The evidence for achievement against this strand should be presented in approximately one A4 page or the equivalent.
Produce a product design specification The required evidence for this strand is: • a design specification that captures both essential and desirable requirements, ensuring that the redesigned product meets the needs of the intended user. The evidence for achievement against this strand should be presented in approximately three A4 pages or the equivalent.

Criterion C: Ideation and modelling

This criterion assesses the student's ability to:

- present a range of annotated, feasible redesign ideas using an appropriate medium(s) to address the problem statement, which can be interpreted by others
- evaluate the redesign ideas against the design specifications through testing and user feedback.

Mark	Strand
0	The work does not reach a standard described by the descriptors below.
1–2	The student: • presents fewer than three annotated, feasible redesign ideas to address the problem statement with limited key features • states the difference between the redesign ideas against the design specifications through testing and user feedback.
3–4	The student: • presents three of the best possible annotated, feasible redesign ideas to address the problem statement that includes some key features • describes the difference between the redesign ideas against the design specifications through testing and user feedback.
5–6	The student: • presents three of the best possible annotated, feasible redesign ideas to address the problem statement and all key features • evaluates the redesign ideas against the design specifications through testing and user feedback.

Clarifications for ideation and modelling
Present feasible redesign ideas The required evidence for this strand is: • a range of feasible ideas communicated using sketches/drawings/CAD/images and fidelity models (one to two A4 pages per idea) • the highlighting of additional research and/or feedback enabling iterative development of ideas • annotations (see "Features of the design project" section). The evidence for achievement against this strand should be presented in approximately six A4 pages or the equivalent.
Identify the redesign ideas The required evidence for this strand is: • an annotated presentation drawing of the feasible redesign idea tested against design specifications and user feedback. The evidence for achievement against this strand should be presented in approximately two A4 pages or the equivalent.

Criterion D: Designing a solution

This criterion assesses the student's ability to:

- develop and annotate iterative fidelity models through multiple testing and refinement cycles to arrive at the intended redesigned solution that addresses the problem statement, design specifications and needs of the intended user
- design drawings of the intended design solution and its components that aid communication and visualization to a third-party manufacturer.

Mark	Strand
0	The work does not reach a standard described by the descriptors below.

Mark	Strand
1–2	The student: • develops a fidelity model partially addressing the problem statement with limited testing against the design specifications and needs of the intended user • designs and annotates drawings showing limited detail of the intended design solution and its components to communicate to a third-party manufacturer.
3–4	The student: • develops a fidelity model satisfactorily addressing the problem statement that outlines the testing against the design specifications and the needs of the intended user • designs and annotates drawings showing adequate details of the intended design solution and its components to communicate to a third-party manufacturer.
5–6	The student: • develops a fidelity model thoroughly addressing the problem statement that evaluates the testing against all of the design specifications and the needs of the intended user • designs and annotates drawings showing comprehensive details of the intended design solution and its components to communicate to a third-party manufacturer.

Clarifications for designing a solution
Develop fidelity models The required evidence for this strand is: • annotated drawings (visual representations such as informal or formal design drawing or sketches, photos of physical models, or CAD) of the multiple testing and refinement cycle through intended user testing to align with the requirements stated in the design specifications. Annotations must not be more than 10 words each. Any annotation more than 10 words will be considered as counting towards the word count. The evidence for achievement against this strand should be presented in approximately six A4 pages or the equivalent.
Design drawings of the intended solution The required evidence for this strand is: • formal design drawings used to represent the completed redesigned solution • a range of formal assembled, exploded and orthographic annotated drawings—including dimensions, proportions and assembly of the solution and its components—are there to aid communication and visualization to a third-party manufacturer. Note that: • there should be approximately one to two images per page • there should be annotations (see "Features of the design project" section). The evidence for achievement against this strand should be presented in approximately four A4 pages or the equivalent.

Criterion E: Presenting a solution

This criterion assesses the student's ability to:

- present the intended redesign solution and annotate the key features
- present how the application of the redesigned solution compares with the existing product and how it addresses the identified problems.

Mark	Strand
0	The work does not reach a standard described by the descriptors below.
1–2	The student: • presents the redesigned solution with limited annotations of its key features • presents how the redesigned solution compares with the existing product.
3–4	The student: • presents the redesigned solution with adequate annotations of its key features • presents how the redesigned solution compares with the existing product and addresses some of the identified problems.
5–6	The student: • presents the redesigned solution with comprehensive annotations of its key features • presents how the redesigned solution compares with the existing product and comprehensively addresses the identified problems.

Clarifications for presenting a solution

Present the intended redesign solution

The required evidence for this strand is:

- the redesigned annotated product and the key features. Annotations must not be more than 10 words each. Any annotation more than 10 words will be considered as counting towards the word count
- approximately two to three images per page.

Note the following.

- The student is required to present the intended solution as though to a third-party manufacturer, using appropriate visual communication methods that can be created by hand or CAD. This should showcase the product's features and may include perspective, exploded, assembly, orthographic, net development, cutaway views, and FEA, etc.
- The presentation itself (style of delivery, medium used) is not formally assessed.

The evidence for achievement against this strand should be presented in two A4 pages or the equivalent.

Present how the intended redesign solution improves on the existing product

The required evidence for this strand is:

- a description of how the student's solution compares with the original product that was identified at the start of the project for redesign.

The evidence for achievement against this strand should be presented in two A4 pages or the equivalent.

Glossary of command terms

Command terms for design technology

Students should be familiar with the following key terms and phrases used in examination questions, which are to be understood as described below. Although these terms will be used frequently in examination questions, other terms may be used to direct students to present an argument in a specific way.

These command terms indicate the depth of treatment required.

Assessment objective 1

Command term	Definition
Label	Add a title, labels or brief explanations(s) to a diagram or graph.
List	Give a sequence of brief answers with no explanation.
State	Give a specific name, value or other brief answer without explanation or calculation.

Assessment objective 2

Command term	Definition
Apply	Use an idea, equation, principle, theory or law in relation to a given problem or issue.
Demonstrate	Make clear by reasoning or evidence, illustrating with examples or practical application.
Describe	Give a detailed account.
Identify	Provide an answer from a number of possibilities.
Outline	Give a brief account or summary.
Present	Offer for display, observation, examination or consideration.

Assessment objective 3

Command term	Definition
Analyse	Break down in order to bring out the guiding elements or structure.
Construct	Display information in a diagrammatic or logical form.
Design	Produce a plan, simulation or model.
Evaluate	Make an appraisal by weighing up the strengths and limitations.
Explain	Give a detailed account including reasons or causes.
Justify	Give valid reasons or evidence to support an answer or conclusion.

Bibliography

This bibliography lists a range of works used to inform the curriculum review. It is not an exhaustive list and does not include all the literature available; judicious selection was made in order to better advise and guide teachers. This bibliography is not a list of recommended textbooks.

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