Diploma Programme

Sports, exercise and health science guide

First assessment 2018

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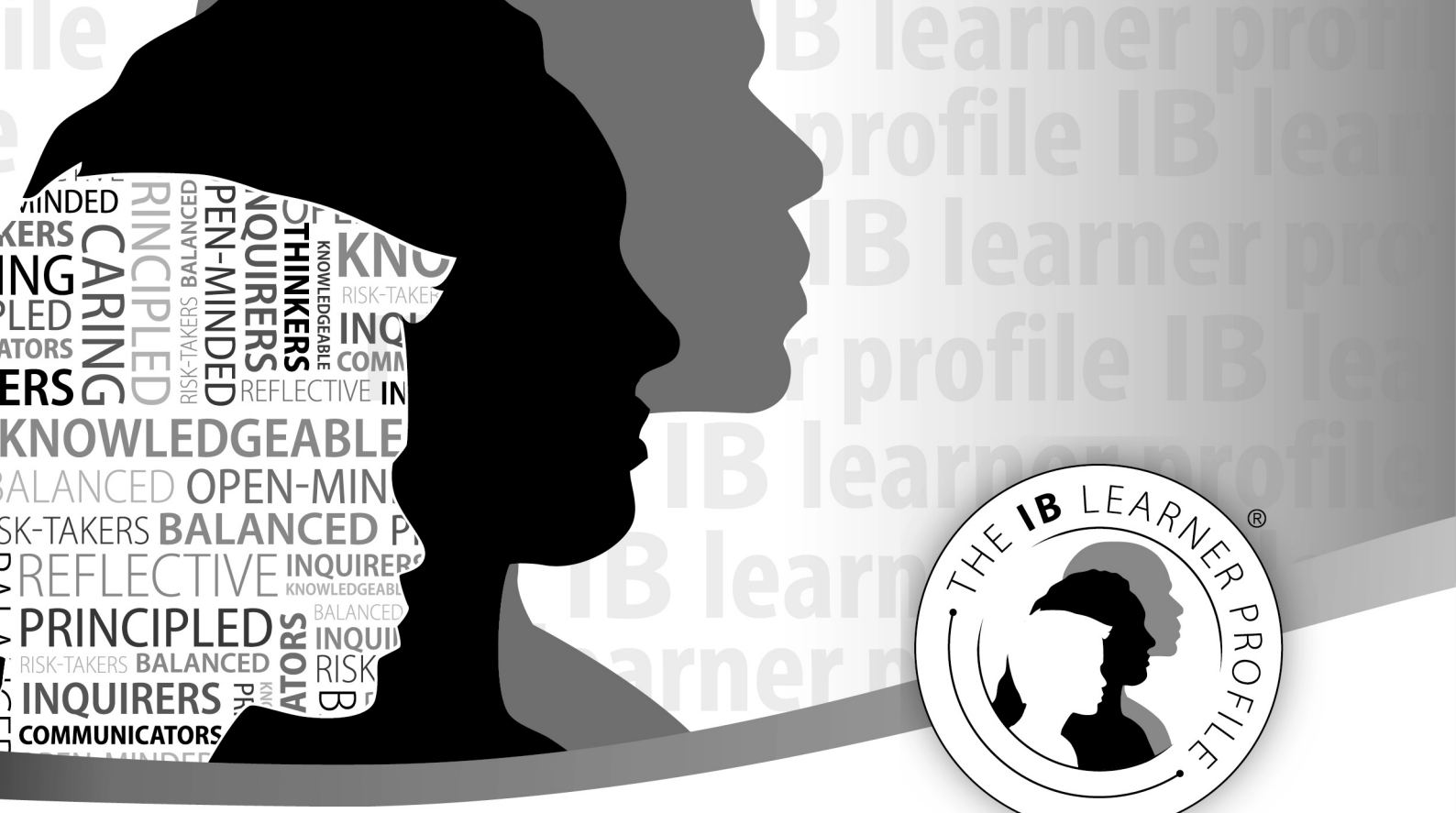
IB mission statement

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 the subject 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 online curriculum centre (OCC) at occ.ibo.org, a password-protected IB website designed to support 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, subject reports and grade descriptors can also be found on the OCC. Past examination papers as well as markschemes can be purchased from the IB store.

Teachers are encouraged to check the OCC 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.

Acknowledgment

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

First assessment 2018

The Diploma Programme

The Diploma Programme 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 Diploma Programme 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 Diploma Programme 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 his or her own perspectives and how they might differ from others.

Creativity, activity, service (CAS) is at the heart of the Diploma Programme. CAS enables students to live out the IB learner profile in real and practical ways, to grow as unique individuals and to recognize their role in relation to others. Students develop skills, attitudes and dispositions through a variety of individual and group experiences that provides students with opportunities to explore their interests and express their passions, personalities and perspectives. CAS complements a challenging academic programme in a holistic way, providing opportunities for self-determination, collaboration, accomplishment and enjoyment.

The three strands of CAS are:

- **creativity**—exploring and extending ideas leading to an original or interpretive product or performance
- **activity**—physical exertion contributing to a healthy lifestyle
- **service**—collaborative and reciprocal engagement with the community in response to an authentic need.

The extended essay, including the world studies extended essay, 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 teaching and learning

Approaches to teaching and learning across the Diploma Programme 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 Diploma Programme assessment and beyond. The aims of approaches to teaching and learning in the Diploma Programme 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' Diploma Programme experience
- allow schools to identify the distinctive nature of an IB Diploma Programme education, with its blend of idealism and practicality.

The five approaches to learning (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.

Academic honesty

Academic honesty in the Diploma Programme is a set of values and behaviours informed by the attributes of the learner profile. In teaching, learning and assessment, academic honesty 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 honesty in the IB and the Diploma Programme, please consult the IB publications *Academic honesty*, *The Diploma Programme: From principles into practice* and *General regulations: Diploma Programme*. Specific information regarding academic honesty as it pertains to external and internal assessment components of this Diploma Programme subject can be found in this guide.

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 *Candidates with assessment access requirements* and *Learning diversity in the International Baccalaureate programmes: Special educational needs within the International Baccalaureate programmes*.

Nature of the subject

Sports, exercise and health science

Sports, exercise and health science (SEHS) is an experimental science that combines academic study with the acquisition of practical and investigative skills. It is an applied science course within group 4, with aspects of biological and physical science being studied in the specific context of sports, exercise and health. Moreover, the subject matter goes beyond the traditional science subjects to offer a deeper understanding of the issues related to sports, exercise and health in the 21st century. Apart from being worthy of study in its own right, SEHS is a good preparation for courses in higher or further education related to sports fitness and health, and serves as useful preparation for employment in sports and leisure industries.

The attainment of excellence in sports is the result of innate ability or skill and the dedicated pursuit of a programme of physical and mental training accompanied by appropriate nutrition. Training programme design should not be left to chance. Rather, it should be designed thoughtfully and analytically after careful consideration of the physiological, biomechanical and psychological demands of the activity. This is the role of the sports and exercise scientist who, regardless of the athletic event, should be equipped with the necessary knowledge to be able to perform this task competently. Furthermore, in a world where many millions of people are physically inactive and afflicted by chronic disease and ill health, the sports and exercise scientist should be equally proficient when prescribing exercise for the promotion of health and well-being.

Scientific inquiry, conducted over many decades, has accumulated a vast amount of information across a range of sub-disciplines that contribute to our understanding of health and human performance in relation to sports and exercise. The Diploma Programme course in sports, exercise and health science involves the study of the science that underpins physical performance and provides the opportunity to apply these principles.

The course incorporates the traditional disciplines of anatomy and physiology, biomechanics, psychology and nutrition, which are studied in the context of sports, exercise and health. Students will cover a range of core and option topics, and carry out practical (experimental) investigations in both laboratory and field settings. This will provide an opportunity to acquire the knowledge and understanding necessary to apply scientific principles and critically analyse human performance. Where relevant, the course will address issues of international dimension and ethics by considering sports, exercise and health relative to the individual and in a global context.

At the school level, both theory and practical work should be undertaken by all students. They should complement one another naturally, as they do in wider scientific study. The Diploma Programme SEHS course allows students to develop practical skills and techniques, and to increase facility in the use of mathematics, which is the language of science. It also allows students to develop interpersonal skills and digital technology skills, which are essential in 21st-century scientific endeavour and are important life-enhancing, transferable skills in their own right. The course is available at both standard level (SL) and higher level (HL), and therefore accommodates students who wish to study SEHS as their major subject in higher education and those who do not.

Distinction between SL and HL

Group 4 students at standard level (SL) and higher level (HL) undertake a common core syllabus, a common internal assessment (IA) scheme and have some overlapping elements in the options studied. They are presented with a syllabus that encourages the development of certain skills, attributes and attitudes, as described in the "Assessment objectives" section of this guide.

While the skills and activities of group 4 science subjects are common to students at both SL and HL, students at HL are required to study additional higher level (AHL) material as well as HL topics within the options. The distinction between SL and HL is one of breadth and depth.

SEHS and the core

SEHS and theory of knowledge

The theory of knowledge (TOK) course (first assessment 2015) engages students in reflection on the nature of knowledge and on how we know what we claim to know. The course identifies eight ways of knowing: reason, emotion, language, sense perception, intuition, imagination, faith and memory. Students explore these means of producing knowledge within the context of various areas of knowledge: the natural sciences, the social sciences, the arts, ethics, history, mathematics, religious knowledge systems and indigenous knowledge systems. The course also requires students to make comparisons between the different areas of knowledge, reflecting on how knowledge is arrived at in the various disciplines, what the disciplines have in common, and the differences between them.

TOK lessons can support students in their study of science, just as the study of science can support students in their TOK course. TOK provides a space for students to engage in stimulating wider discussions about questions such as what it means for a discipline to be a science, or whether there should be ethical constraints on the pursuit of scientific knowledge. It also provides an opportunity for students to reflect on the methodologies of science, and how these compare to the methodologies of other areas of knowledge. It is now widely accepted that there is no one scientific method, in the strict Popperian sense. Instead, the sciences utilize a variety of approaches in order to produce explanations for the behaviour of the natural world. The different scientific disciplines share a common focus on utilizing inductive and deductive reasoning, on the importance of evidence, and so on. Students are encouraged to compare and contrast these methods with the methods found in, for example, the arts or in history.

In this way there are rich opportunities for students to make links between their science and TOK courses. One way in which science 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 open-ended questions about knowledge, and include questions such as the following.

- How do we distinguish science from pseudoscience?
- When performing experiments, what is the relationship between a scientist's expectation and their perception?
- How does scientific knowledge progress?
- What is the role of imagination and intuition in the sciences?
- What are the similarities and differences in methods in the natural sciences and the human sciences?

Examples of relevant knowledge questions are provided throughout this guide within the sub-topics in the syllabus content. Teachers can also find suggestions of interesting knowledge questions for discussion in the "Areas of knowledge" and "Knowledge framework" sections of the *Theory of knowledge guide*. Students should be encouraged to raise and discuss such knowledge questions in both their science and TOK classes.

SEHS and CAS

There are strong links between SEHS and CAS that both teachers and students can explore. In SEHS students actively engage with issues related to exercise and health that can naturally lead into CAS experiences. All three strands of CAS can be incorporated into experiences that relate to SEHS within local, national and global communities.

Examples of these strands include:

- creating a campaign to encourage healthy eating in the school canteen
- regularly taking part in sports, either as a competitive athlete/team member, or participating regularly in a fitness activity working towards a given health or fitness objective
- working alongside a community organization as a coach, mentor or facilitator to provide sporting opportunities for children in the local community.

Science and international-mindedness

Science itself is an international endeavour—the exchange of information and ideas across national boundaries has been essential to the progress of science. This exchange is not a new phenomenon but it has accelerated in recent times with the development of information and communication technologies. Indeed, the idea that science is a Western invention is a myth—many of the foundations of modern-day science were laid many centuries before by Arabic, Indian and Chinese civilizations, among others. Teachers are encouraged to emphasize this contribution in their teaching of various topics, perhaps through the use of timeline websites. The scientific method in its widest sense, with its emphasis on peer review, open-mindedness and freedom of thought, transcends politics, religion, gender and nationality. Where appropriate within certain topics, the syllabus details sections in the group 4 guides contain links illustrating the international aspects of science.

At an organizational level, many international bodies now exist to promote science. United Nations bodies such as the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO), where science plays a prominent part, are well known. In addition, there are hundreds of international bodies representing every branch of science. In the area of sports, organizations such as the International Olympic Committee (IOC), the International Paralympic Committee (IPC), the International Council of Sport Science and Physical Education (ICSSPE) and the World Anti-Doping Agency (WADA) specifically promote global understanding of issues relating to sports and health. The resources required for large-scale research in, for example, the Human Genome Project or the abuse of performance-enhancing substances are expensive, and only joint ventures involving funding from many countries allow this to take place. The data from such research is shared by scientists worldwide. Group 4 teachers and students are encouraged to access the extensive websites and databases of these international scientific organizations to enhance their appreciation of the international dimension.

Increasingly there is a recognition that many scientific problems are international in nature and this has led to a global approach to research in many areas. The work of the World Health Organization (WHO) in eradicating smallpox is a prime example of this. On a practical level, the group 4 project (which all science students must undertake) mirrors the work of real scientists by encouraging collaboration between schools across the regions.

The power of scientific knowledge 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, group 4 students need to be aware of the moral responsibility of scientists to ensure that scientific knowledge and data are available to all countries on an equitable basis and that they have the scientific capacity to use this for developing sustainable societies.

Students' attention should be drawn to sections of the syllabus with links to international-mindedness. Examples of issues relating to international-mindedness are given within sub-topics in the syllabus content. Teachers could also use resources found on the teacher resource exchange.

Aims

Through studying any of the group 4 subjects, students should become aware of how scientists work and communicate with each other. While the "scientific method" may take on a wide variety of forms, it is the emphasis on a practical approach through experimental work that distinguishes the group 4 subjects from other disciplines and characterizes each of the subjects within group 4.

It is in this context that the Diploma Programme sports, exercise and health science course should aim to:

1. appreciate scientific study and creativity within a global context through stimulating and challenging opportunities
2. acquire a body of knowledge, methods and techniques that characterize science and technology
3. apply and use a body of knowledge, methods and techniques that characterize science and technology
4. develop an ability to analyse, evaluate and synthesize scientific information
5. develop a critical awareness of the need for, and the value of, effective collaboration and communication during scientific activities
6. develop experimental and investigative scientific skills including the use of current technologies
7. develop and apply 21st-century communication skills in the study of science
8. become critically aware, as global citizens, of the ethical implications of using science and technology
9. develop an appreciation of the possibilities and limitations of science and technology
10. develop an understanding of the relationships between scientific disciplines and their influence on other areas of knowledge.

Assessment objectives

The assessment objectives for all group 4 subjects reflect those parts of the aims that will be assessed. Wherever appropriate, the assessment will draw upon environmental and technological contexts and identify the social, moral and economic effects of science.

It is the intention of the Diploma Programme sports exercise and health science course that students achieve the following objectives.

1. Demonstrate knowledge and understanding of:
    a. facts, concepts and terminology
    b. methodologies and techniques
    c. communicating scientific information.
2. Apply:
    a. facts, concepts and terminology
    b. methodologies and techniques
    c. methods of communicating scientific information.
3. Formulate, analyse and evaluate:
    a. hypotheses, research questions and predictions
    b. methodologies and techniques
    c. primary and secondary data
    d. scientific explanations.
4. Demonstrate the appropriate research, experimental and personal skills necessary to carry out insightful and ethical investigations.

Assessment objectives in practice

SL

Component	Overall weighting (%)	Approximate weighting of objectives (%)		Duration	Format and syllabus coverage
		1–2	3		
Paper 1	20	20	0	45 minutes	30 multiple-choice questions on the core syllabus
Paper 2	35	17.5	17.5	1 hour 15 minutes	Section A: one data-based question and several short-answer questions on the core (all compulsory) Section B: one extended-response question on the core (from a choice of three)
Paper 3	25	12.5	12.5	1 hour	Several short-answer questions (all compulsory) in each of the two options studied
Internal assessment	20	Covers objectives 1, 2, 3 and 4		10 hours	Individual investigation

HL

Component	Overall weighting (%)	Approximate weighting of objectives (%)		Duration	Format and syllabus coverage
		1–2	3		
Paper 1	20	20	0	1 hour	40 multiple-choice questions (±15 common to SL plus about 5 more on the core and about 20 more on the AHL)
Paper 2	35	17.5	17.5	2 hours 15 minutes	Section A: one data-based question and several short-answer questions on the core and AHL topics (all compulsory) Section B: two extended-response questions on the core and AHL (from a choice of four)
Paper 3	25	12.5	12.5	1 hour 15 minutes	Several short-answer and extended-response questions (all compulsory) in each of the two options studied
Internal Assessment	20	Covers objectives 1, 2, 3 and 4		10 hours	Individual investigation

In addition to addressing objectives 1, 2 and 3, the internal assessment scheme (overall weighting 20%) addresses objective 4.

Classification of command terms

Key command terms are used in the syllabus content under the "Assessment statement" column, as described in the "Structure of the syllabus" section, to indicate the depth of understanding that is required of students. These are classified below according to the assessment objectives (AOs).

- AO1 Demonstrate knowledge and understanding
- AO2 Apply
- AO3 Formulate, analyse and evaluate

There is a progression in demand from AO1 to AO3. Students must also be familiar with the command terms to understand the depth of treatment required in examination questions. A command term used in an examination question will either be from the same classification as specified in the "Assessment statement" column or a less demanding command term. For example, if the command term in the assessment statement is "outline", and is classified as AO2, an examination question could contain the command term "outline". Alternatively, another command term such as "describe", which is also classified as AO2, could be used, or one associated with AO1, such as "state". The allocation of marks in examination questions also reflects this classification of the assessment objectives.

Syllabus outline

Syllabus component	Teaching hours	
	SL	HL
Core There are six compulsory topics in the core.	**80**	
1. Anatomy	7	
2. Exercise physiology	17	
3. Energy systems	13	
4. Movement analysis	15	
5. Skill in sports	15	
6. Measurement and evaluation of human performance	13	
Additional higher level There are seven additional topics for higher level.		**50**
7. Further anatomy		7
8. The endocrine system		7
9. Fatigue		6
10. Friction and drag		8
11. Skill acquisition and analysis		9
12. Genetics and athletic performance		7
13. Exercise and immunity		6
Options There are four options. Students are required to study any two options. A. Optimizing physiological performance B. Psychology of sports C. Physical activity and health D. Nutrition for sports, exercise and health	**30**	**50**
Practical work	**40**	**60**
Total teaching hours	**150**	**240**

The recommended teaching time is 240 hours to complete HL courses and 150 hours to complete SL courses as stated in the document *General regulations: Diploma Programme* (page 6 article 8.2).

Approaches to the teaching of SEHS

There are a variety of approaches to the teaching of SEHS. By its very nature, SEHS lends itself to a practical approach, and it is expected that this will be reflected throughout the course.

The order in which the syllabus is arranged is **not** the order in which it should be taught, and it is up to individual teachers to decide on an arrangement that suits their circumstances. Sections of the option material may be taught within the core or the additional higher level (AHL) material if desired, or the option material can be taught as separate units.

Engaging with sensitive topics

As part of the SEHS course, students will be required to think about, and evaluate, their own lifestyle choices, and to engage with those of others. There are frequent opportunities for debate of ethical issues relating to sports, ranging from the healthy eating choices of individuals to inclusive sports policies in elite competitions.

Students and teachers may therefore encounter conflict between their own values and beliefs in relation to health, and those of others. There may well be situations where social and cultural pressures impact on an individual's understanding of health issues, and discussing such pressures could even influence their lifestyle choices in a positive or negative way. Teachers are advised to respond to these issues in a sensitive way.

Prior learning

Past experience shows that students will be able to study a group 4 science subject at SL successfully with no background in, or previous knowledge of, science. Their approach to learning, characterized by the IB learner profile attributes, will be significant here.

However, for most students considering the study of a group 4 subject at HL, while there is no intention to restrict access to group 4 subjects, some previous exposure to formal science education would be necessary. Specific topic details are not specified but students who have undertaken the IB Middle Years Programme (MYP) or studied an equivalent national science qualification or a school-based science course would be well prepared for an HL subject.

Links to the Middle Years Programme

Students who have undertaken the MYP science, design and mathematics courses will be well prepared for group 4 subjects. The alignment between MYP science and DP group 4 courses allows for a smooth transition for students between programmes.

Scientific inquiry is central to teaching and learning science in the MYP. It enables students to develop a way of thinking and a set of skills and processes that, while allowing them to acquire and use knowledge, equip them with the capabilities to tackle, with confidence, the internal assessment component of group 4 subjects. The vision of MYP sciences is to contribute to the development of students as 21st-century learners.

A holistic sciences programme allows students to develop and utilize a mixture of cognitive abilities, social skills, personal motivation, conceptual knowledge and problem-solving competencies within an inquiry-based learning environment (Rhoton 2010). Inquiry aims to support students' understanding by providing them with opportunities to independently and collaboratively investigate relevant issues through both research and experimentation. This forms a firm base of scientific understanding with deep conceptual roots for students entering group 4 courses.

In the MYP, teachers make decisions about student achievement using their professional judgment, guided by criteria that are public, precise and known in advance, ensuring that assessment is transparent. The IB describes this approach as "criterion-related"—a philosophy of assessment that is neither "norm-referenced" (where students must be compared to each other and to an expected distribution of achievement) nor "criterion-referenced" (where students must master all strands of specific criteria at lower achievement levels before they can be considered to have achieved the next level). It is important to emphasize that the single most important aim of MYP assessment (consistent with the Primary Years Programme and DP) is to support curricular goals and encourage appropriate student learning. Assessments are based upon evaluating course aims and objectives and, therefore, effective teaching to the course requirements also ensures effective teaching for formal assessment requirements. Students need to understand what the assessment expectations, standards and practices are, and these should all be introduced early and naturally in teaching, as well as in class and homework activities. Experience with criterion-related assessment greatly assists students entering group 4 courses with understanding internal assessment requirements.

MYP science is a concept-driven curriculum, aimed at helping the learner construct meaning through improved critical thinking and the transfer of knowledge. At the top level are key concepts, which are broad, organizing, powerful ideas that have relevance within the science course but also transcend it, having relevance in other subject groups. These key concepts facilitate both disciplinary and interdisciplinary learning as well as making connections with other subjects. While the key concepts provide breadth, the related concepts in MYP science add depth to the programme. The related concept can be considered to be the big idea of the unit that brings focus and depth, and leads students towards the conceptual understanding.

Across the MYP, there are 16 key concepts, with the three highlighted below as the focus for MYP science.

The key concepts across the MYP curriculum			
Aesthetics	**Change**	Communication	Communities
Connections	Creativity	Culture	Development
Form	Global interactions	Identity	Logic
Perspective	**Relationships**	**Systems**	Time, place and space

MYP students may in addition undertake an optional on-screen concept-based assessment as further preparation for DP science courses.

Curriculum model

A common curriculum model applies to all the DP group 4 subjects. (There are some differences in this model for design technology and these arise from the design project, which is a unique feature of this subject.) Students study a core syllabus, and this is supplemented by the study of options.

Students at SL are required to spend 40 hours on practical/investigative work. This includes 10 hours for the group 4 project.

SL group 4 curriculum model

SL	Total teaching hours	150
Theory		**110**
	Core	80
	Options	30
Practical work		**40**
	Investigations	20
	Group 4 project Individual Investigation (IA)	10 10

HL group 4 curriculum model

HL	Total teaching hours	240
Theory		**180**
	Core	130
	Options	50
Practical work		**60**
	Investigations	40
	Group 4 project Individual investigation (IA)	10 10

Structure of the syllabus

Note: The order in which the syllabus content is presented is not intended to represent the order in which it should be taught.

The structure is as follows.

Topics or options

Topics are numbered and options are indicated by a letter (for example, "Topic 5: Skill in sports" or "Option D: Nutrition for sports, exercise and health").

Sub-topics

Sub-topics are numbered and the estimated teaching time required to cover the material is indicated (for example, "3.1 Nutrition (4 hours)"). These times are for guidance only and do not include time for practical/investigative work.

Assessment statements

Assessment statements (AS), which are numbered, are expressed in terms of the outcomes that are expected of students at the end of the course (for example, "2.1.2 Outline the functions of the conducting airways"). These are intended to prescribe to examiners what can be assessed by means of the written examinations. Each one is classified as assessment objective 1, 2 or 3 according to the command terms used (see the "Glossary of command terms" section). The assessment objective levels are relevant for the examinations and for balance within the syllabus, while the command terms indicate the depth of treatment required for a given assessment statement. It is important that students are made aware of the meanings of the command terms because these will be used in examination questions. (When the command term "define" is used, the word(s) or phrase to be defined is in italics. When the command term "distinguish" is used, the terms or concepts to be distinguished are also in italics.)

Teacher's notes

Teacher's notes, which are included alongside some assessment statements, provide further guidance to teachers.

They may also suggest ideas for the promotion of aim 7, aim 8, aim 9, TOK and the international dimension (Int).

Topic 1: Anatomy (7 hours) ← Topic or option

1.1 The skeletal system ← Sub-topic

4 hours

	Assessment statement	Obj	Teacher's notes
1.1.1	Distinguish anatomically between the *axial* and *appendicular* skeleton.	2	Axial skeleton: limit to the skull, ribs, sternum and vertebral column consisting of cervical—7 bones; thoracic—12 bones; lumbar—5 bones; sacral—5 bones (fused as 1); coccyx—4 bones (fused as 1). Appendicular skeleton: limit to the pectoral girdle (scapulae and clavicles), humerus, radius, ulna, carpals, metacarpals, phalanges, pelvic girdle (ilium, ischium and pubis), femur, patella, tibia, fibula, tarsals, metatarsals and phalanges. ← Teacher's notes
1.1.2	Distinguish between the *axial* and *appendicular* skeleton in terms of function. ← Assessment statement	2	Consider the anatomical functions attachment, protection, movement and support.
1.1.3	State the four types of bone.	1 ← Objective	Limit to long, short, flat and irregular.
1.1.4	Draw and annotate the structure of a long bone.	2	Limit to: • epiphysis • spongy bone • articular cartilage • diaphysis • compact bone • bone marrow • marrow cavity • blood vessel • periosteum.

Further guidance

Use of information and communication technology

In accordance with aim 7, the use of information and communication technology (ICT) is strongly encouraged throughout the course in both practical and theory work.

Practical work

An essential aspect of the course is hands-on work in the laboratory and/or out in the field. The syllabus not only directly requires the use of field techniques, but many components can only be covered effectively through this approach. Practical work in this subject is an opportunity to gain and develop skills and techniques beyond the requirements of the assessment model and should be fully integrated with the teaching of the course.

Mathematical requirements

All DP sports, exercise and health science students should be able to:

- perform the basic arithmetic functions: addition, subtraction, multiplication and division
- carry out simple calculations involving means, decimals, fractions, percentages, ratios, approximations, reciprocals and scaling
- use scientific notation (for example, 3.6×10^6)
- use direct and inverse proportion
- represent and interpret frequency data in the form of bar charts, column graphs and histograms, and interpret pie charts
- determine the mode and median of a set of data, calculate and analyse standard deviation
- select statistical tests appropriate for the analysis of particular data and interpret the results
- plot and interpret graphs (with suitable scales and axes) involving two variables that show linear or non-linear relationships
- plot and interpret scattergrams to identify a correlation between two variables, and appreciate that the existence of a correlation does not establish a causal relationship
- recognize and use the relationships between length, surface area and volume.

Teacher support materials

A variety of teacher support materials will accompany this guide. These materials will include guidance for teachers on the introduction, planning and marking of the internal assessment, and specimen examination papers and markschemes.

The online curriculum centre

All teachers of the SEHS course are strongly encouraged to access the online curriculum centre (OCC) at regular intervals. The OCC is a website on which all teachers can post inquiries, present examples of good practice, ask for advice and access exemplar materials. The content of the "Sports, exercise and health science forum" on the OCC is provided by SEHS teachers for SEHS teachers.

The IB learner profile

The SEHS syllabus is closely linked to the IB learner profile. By following the syllabus, students will have addressed the attributes of the IB learner profile. For example, the requirements of the internal assessment provide opportunities for students to develop every aspect of the profile. For each attribute of the learner profile, a number of examples selected from the SEHS syllabus are given below.

Learner profile attribute	Sports, exercise and health science syllabus
Inquirers	Content: Core, AHL and options Practical work and internal assessment
Knowledgeable	Content: Int links Practical work and internal assessment: group 4 project
Thinkers	Content: TOK links Practical work and internal assessment
Communicators	Written material: Extended responses and investigations Practical work and internal assessment
Principled	Content: Core, AHL and options (for example, Option A.3, D.4), Aim 8 Ethical behaviour/practice (*Ethical practice poster, Animal experimentation policy*), consideration of ethical implications, authenticity
Open-minded	Content: Aim 8, Aim 9, Int, TOK links Practical work and internal assessment: group 4 project Evaluate sources of scientific information in terms of reliability, bias, relevance and accuracy
Caring	Content: Aim 8 Practical work and internal assessment Ethical behaviour/practice (*Ethical practice poster, Animal experimentation policy*), consideration of ethical implications
Risk-takers	Practical work and internal assessment: group 4 project
Balanced	This course particularly encourages this attribute of the IB learner profile, promoting the importance of intellectual and physical balance to achieve personal well-being. Content: Core, AHL and options Practical work and internal assessment
Reflective	Practical work and internal assessment: group 4 project

The practical work, ICT and the learner profile taken together form the basis for pedagogy recommended for the course. Using technology for practical hands-on activities in the laboratory and the field is the dominant delivery method and process for teaching and learning.

Syllabus content—Core

Topic 1: Anatomy (7 hours)

1.1 The skeletal system

4 hours

	Assessment statement	Obj	Teacher's notes
1.1.1	Distinguish anatomically between the *axial* and *appendicular* skeleton.	2	Axial skeleton: limit to the skull, ribs, sternum and vertebral column consisting of cervical—7 bones; thoracic—12 bones; lumbar—5 bones; sacral—5 bones (fused as 1); coccyx—4 bones (fused as 1). Appendicular skeleton: limit to the pectoral girdle (scapulae and clavicles), humerus, radius, ulna, carpals, metacarpals, phalanges, pelvic girdle (ilium, ischium and pubis), femur, patella, tibia, fibula, tarsals, metatarsals and phalanges.
1.1.2	Distinguish between the *axial* and *appendicular* skeleton in terms of function.	2	Consider the anatomical functions attachment, protection, movement and support.
1.1.3	State the four types of bone.	1	Limit to long, short, flat and irregular.
1.1.4	Draw and annotate the structure of a long bone.	2	Limit to: • epiphysis • spongy bone • articular cartilage • diaphysis • compact bone • bone marrow • marrow cavity • blood vessel • periosteum.

	Assessment statement	Obj	Teacher's notes
1.1.5	Apply anatomical terminology to the location of bones.	2	Limit to: • inferior • superior • proximal • distal • medial • lateral • posterior • anterior. Limit to the bones listed in the axial and appendicular skeleton (see 1.1.1). Assume anatomical position.
1.1.6	Outline the functions of connective tissue.	2	Limit to cartilage, ligament and tendon.
1.1.7	Define the term *joint*.	1	A joint occurs where two or more bones articulate.
1.1.8	Distinguish between the different types of joint in relation to movement permitted.	2	Limit to fibrous, cartilaginous and synovial joints.
1.1.9	Outline the features of a synovial joint.	2	Limit to: • articular cartilage • synovial membrane • synovial fluid • bursae • meniscus • ligaments • articular capsule.
1.1.10	List the different types of synovial joint.	1	Consider hinge, ball and socket, condyloid, pivot, gliding and saddle.

1.2 The muscular system

3 hours

	Assessment statement	Obj	Teacher's notes
1.2.1	Outline the general characteristics common to muscle tissue.	2	Limit to: • contractility • extensibility • elasticity • atrophy • hypertrophy • controlled by nerve stimuli and fed by capillaries.
1.2.2	Distinguish between the different types of muscle.	2	Include smooth, cardiac and skeletal.
1.2.3	Annotate the structure of skeletal muscle.	2	Limit to: • epimysium • perimysium • endomysium • muscle fibre • myofibril • sarcomere • actin • myosin.
1.2.4	Define the terms *origin* and *insertion* of muscles.	1	Origin: the attachment of a muscle tendon to a stationary bone. Insertion: the attachment of a muscle tendon to a moveable bone.

	Assessment statement	Obj	Teacher's notes
1.2.5	Identify the location of skeletal muscles in various regions of the body.	2	Include the muscles from: • the anterior – deltoid – pectoralis – iliopsoas – sartorius – quadriceps – femoris (rectus femoris, vastus intermedialis, vastus medialis, vastus lateralis) – tibialis anterior – abdominus rectus – external obliques – biceps brachii • the posterior – trapezius – triceps brachii – latissimus dorsi – gluteus maximus – hamstrings (biceps femoris, semitendinosus, semimembranosus) – gastrocnemius – soleus – erector spinae.

Topic 2: Exercise physiology (17 hours)

2.1 Structure and function of the ventilatory system

5 hours

Aim 7: There are numerous technologies used to facilitate direct measurement in respiratory research (for example, spirometer, online gas analysis).

	Assessment statement	Obj	Teacher's notes
2.1.1	List the principal structures of the ventilatory system.	1	• Nose • Mouth • Pharynx • Larynx • Trachea • Bronchi • Bronchioles • Lungs • Alveoli. Cross reference to 1.2.2.
2.1.2	Outline the functions of the conducting airways.	2	Limit to: • low resistance pathway for airflow • defence against chemicals and other harmful substances that are inhaled • warming and moistening the air.
2.1.3	Define the terms *pulmonary ventilation, total lung capacity (TLC), vital capacity (VC), tidal volume (TV), expiratory reserve volume (ERV), inspiratory reserve volume (IRV)* and *residual volume (RV).*	1	Pulmonary ventilation: inflow and outflow of air between the atmosphere and the lungs (also called breathing). Total lung capacity: volume of air in the lungs after a maximum inhalation. Vital capacity: maximum volume of air that can be exhaled after a maximum inhalation. Tidal volume: volume of air breathed in and out in any one breath. Expiratory reserve volume: volume of air in excess of tidal volume that can be exhaled forcibly. Inspiratory reserve volume: additional inspired air over and above tidal volume. Residual volume: volume of air still contained in the lungs after a maximal exhalation.

	Assessment statement	Obj	Teacher's notes
2.1.4	Explain the mechanics of ventilation in the human lungs.	3	Include the actions of the diaphragm and the intercostal muscles, and the relationship between volume and pressure. Students should be aware that accessory muscles are also important during strenuous exercise.
2.1.5	Describe nervous and chemical control of ventilation during exercise.	2	Limit to ventilation increases as a direct result of increases in blood acidity levels (low pH) due to increased carbon dioxide content of the blood detected by the respiratory centre. This results in an increase in the rate and depth of ventilation. Neural control of ventilation includes lung stretch receptors, muscle proprioreceptors and chemoreceptors. The role of H^+ ions and reference to partial pressure of oxygen are not required.
2.1.6	Outline the role of hemoglobin in oxygen transportation.	2	Most (98.5%) of oxygen in the blood is transported by hemoglobin as oxyhemoglobin within red blood cells.
2.1.7	Explain the process of gaseous exchange at the alveoli.	3	

2.2 Structure and function of the cardiovascular system

12 hours

Aim 7: There are numerous technologies used to facilitate direct measurement in cardiovascular research, for example, interfaced heart rate monitors, blood pressure monitors, ECG monitors.

	Assessment statement	Obj	Teacher's notes
2.2.1	State the composition of blood.	1	Blood is composed of cells (erythrocytes, leucocytes and platelets) and plasma. Blood is also the transport vehicle for electrolytes, proteins, gases, nutrients, waste products and hormones.
2.2.2	Distinguish between the functions of *erythrocytes*, *leucocytes* and *platelets*.	2	
2.2.3	Describe the anatomy of the heart with reference to the heart chambers, valves and major blood vessels.	2	The names of the four chambers, four valves (bicuspid, tricuspid, aortic and pulmonary valves) and the four major blood vessels (vena cava, pulmonary vein, the aorta and pulmonary artery) of the pulmonary and systemic circulation are required. The heart has its own blood supply via the coronary arteries; however, the names of the coronary arteries are not required.

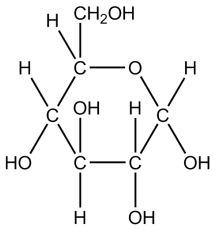
	Assessment statement	Obj	Teacher's notes
2.2.4	Describe the intrinsic and extrinsic regulation of heart rate and the sequence of excitation of the heart muscle.	2	The heart has its own pacemaker, but heart rate is also influenced by the sympathetic and parasympathetic branches of the autonomic nervous system and by adrenaline. (It should be recognized that adrenaline has wider metabolic actions, that is, increasing glycogen and lipid breakdown.) The electrical impulse is generated at the sinoatrial node (SA node) and travels across the atria to the atrioventricular node (AV node) to the ventricles.
2.2.5	Outline the relationship between the pulmonary and systemic circulation.	2	
2.2.6	Describe the relationship between heart rate, cardiac output and stroke volume at rest and during exercise.	2	Cardiac output = stroke volume × heart rate. Stroke volume expands and heart rate increases during exercise.
2.2.7	Analyse cardiac output, stroke volume and heart rate data for different populations at rest and during exercise.	3	Limit to: • males • females • trained • untrained • young • old. Recall of quantitative data is not expected.
2.2.8	Explain cardiovascular drift.	3	An increase of body temperature results in a lower venous return to the heart, a small decrease in blood volume from sweating. A reduction in stroke volume causes the heart rate to increase to maintain cardiac output. Include reference to blood viscosity.
2.2.9	Define the terms *systolic* and *diastolic blood pressure*.	1	Systolic: the force exerted by blood on arterial walls during ventricular contraction. Diastolic: the force exerted by blood on arterial walls during ventricular relaxation.
2.2.10	Analyse systolic and diastolic blood pressure data at rest and during exercise.	3	Recall of quantitative data is not expected.
2.2.11	Discuss how systolic and diastolic blood pressure respond to dynamic and static exercise.	3	

	Assessment statement	Obj	Teacher's notes
2.2.12	Compare the distribution of blood at rest and the redistribution of blood during exercise.	3	Movement of blood in favour of muscles.
2.2.13	Describe the cardiovascular adaptations resulting from endurance exercise training.	2	Limit to increased left ventricular volume resulting in an increased stroke volume and a lower resting and exercising heart rate. Consider also increased capillarization and increased arterio-venous oxygen difference.
2.2.14	Explain maximal oxygen consumption.	3	Maximal oxygen consumption (VO_2max) represents the functional capacity of the oxygen transport system and is sometimes referred to as maximal aerobic power or aerobic capacity.
2.2.15	Discuss the variability of maximal oxygen consumption in selected groups.	3	Consider: • trained versus untrained • males versus females • young versus old • athlete versus non-athlete.
2.2.16	Discuss the variability of maximal oxygen consumption with different modes of exercise.	3	Consider cycling versus running versus arm ergometry.

Topic 3: Energy systems (13 hours)

3.1 Nutrition

4 hours

	Assessment statement	Obj	Teacher's notes
3.1.1	List the macronutrients and micronutrients.	1	Macro: lipid (fat), carbohydrate, water and protein. Micro: vitamins and minerals.
3.1.2	Outline the functions of macronutrients and micronutrients.	2	Specific knowledge of individual vitamins and minerals is not required.
3.1.3	State the chemical composition of a glucose molecule.	1	C, H and O (1:2:1 ratio)
3.1.4	Identify a diagram representing the basic structure of a glucose molecule.	2	
3.1.5	Explain how glucose molecules can combine to form disaccharides and polysaccharides.	3	Condensation reaction—the linking of a monosaccharide to another monosaccharide, disaccharide or polysaccharide by the removal of a water molecule.
3.1.6	State the composition of a molecule of triacylglycerol.	1	Limit to glycerol and three fatty acids.
3.1.7	Distinguish between *saturated* and *unsaturated fatty acids*.	2	Saturated fatty acids have no double bonds between the individual carbon atoms of the fatty acid chain. Saturated fats originate from animal sources, for example, meat, poultry, full-fat dairy products and tropical oils, such as palm and coconut oils. Unsaturated fatty acids contain one or more double bonds between carbon atoms within the fatty acid chain. Unsaturated fats originate from plant-based foods, for example, olive oil, olives, avocado, peanuts, cashew nuts, canola oil and seeds, sunflower oil and rapeseed.
3.1.8	State the chemical composition of a protein molecule.	1	Limit to C, H, O and N.

	Assessment statement	Obj	Teacher's notes
3.1.9	Distinguish between an *essential* and a *non-essential amino acid*.	2	Essential amino acids cannot be synthesized by the human body and must be obtained from diet. Non-essential amino acids can be synthesized by the human body.
3.1.10	Describe current recommendations for a healthy balanced diet.	2	Consider recommendations for carbohydrates, proteins, lipids, fibre, water and salt for adults in the general population. The relative contribution of carbohydrate, protein and lipid (including monounsaturated, polyunsaturated and saturated) should be given. **Aim 9:** Recommended intakes of nutrients have been published in some countries. The recommendations vary and this raises questions about how the levels are decided. **Int/Aim 8:** Students can be made aware of the sociocultural influences of food selection and preparation across populations, for example, Mediterranean, Japanese, Western (USA, UK) and Indian. **TOK:** Justification of how a balanced diet is defined.
3.1.11	State the approximate energy content per 100 g of carbohydrate, lipid and protein.	1	Students should know that the energy content values per 100 g are: carbohydrate 1760 kJ, lipid 4000 kJ and protein 1720 kJ.
3.1.12	Discuss how the recommended energy distribution of the dietary macronutrients differs between endurance athletes and non-athletes.	3	Limit to the important difference in carbohydrate intake and how, therefore, this also affects fat and protein intake. For example, carbohydrate intake is higher, protein and fat intake is slightly higher for a marathon runner than a non-athlete, and vice versa. **Int:** Variation between countries, for example, a high-carbohydrate diet consumed by athletes in some countries. **Aim 8:** Some sports require smaller stature; therefore, diet manipulation may occur prior to competition. **Aim 9:** Recommended intakes vary within published literature. **TOK:** Justification of how diet contributes to performance.

3.2 Carbohydrate and fat metabolism

2 hours

	Assessment statement	Obj	Teacher's notes
3.2.1	Outline metabolism, anabolism, aerobic catabolism and anaerobic catabolism.	2	Metabolism: All the biochemical reactions that occur within an organism, including anabolic and catabolic reactions. Anabolism: Energy requiring reactions whereby small molecules are built up into larger ones. Catabolism: Chemical reactions that break down complex organic compounds into simpler ones, with the net release of energy.
3.2.2	State what glycogen is and its major storage sites.	1	
3.2.3	State the major sites of triglyceride storage.	1	Adipose tissue and skeletal muscle.
3.2.4	Explain the role of insulin in the formation of glycogen and the accumulation of body fat.	3	
3.2.5	Outline glycogenolysis and lipolysis.	2	
3.2.6	Outline the functions of glucagon and adrenaline during fasting and exercise.	2	
3.2.7	Explain the role of insulin and muscle contraction on glucose uptake during exercise.	3	Emphasize that both insulin and muscle contraction stimulate glucose uptake from the blood into skeletal muscle.

3.3 Nutrition and energy systems

7 hours

	Assessment statement	Obj	Teacher's notes
3.3.1	Annotate a diagram of the ultrastructure of a generalized animal cell.	2	The diagram should show ribosomes, rough endoplasmic reticulum, lysosomes, Golgi apparatus, mitochondrion and nucleus.
3.3.2	Annotate a diagram of the ultrastructure of a mitochondrion.	2	Cristae, inner matrix and outer smooth membrane.
3.3.3	Define the term *cell respiration*.	1	Cell respiration is the controlled release of energy in the form of adenosine triphosphate (ATP) from organic compounds in cells.

	Assessment statement	Obj	Teacher's notes
3.3.4	Explain how adenosine can gain and lose a phosphate molecule.	3	
3.3.5	Explain the role of ATP in muscle contraction.	3	Limit to the breakdown of ATP to adenosine diphosphate (ADP) releasing a phosphate molecule, which provides energy for muscle contraction. Cross reference with 4.1.3.
3.3.6	Describe the re-synthesis of ATP by the ATP–CP system.	2	Creatine phosphate (CP), a high energy molecule, is broken down to provide a phosphate molecule for the re-synthesis of ATP that has been utilized during the initial stages of exercise.
3.3.7	Describe the production of ATP by the lactic acid system.	2	Also known as anaerobic glycolysis—the breakdown of glucose to pyruvate without the use of oxygen. Pyruvate is then converted into lactic acid, which limits the amount of ATP produced (two ATP molecules).
3.3.8	Explain the phenomena of oxygen deficit and oxygen debt.	3	Oxygen debt is now known as excess post-exercise oxygen consumption (EPOC).
3.3.9	Describe the production of ATP from glucose and fatty acids by the aerobic system.	2	Limit to: in the presence of oxygen, pyruvate is processed by the Krebs cycle which liberates electrons that are passed through the electron transport chain producing energy (ATP). Fats are also broken down by beta oxidation that liberates a greater number of electrons, thus more ATP. In the presence of oxygen, and in extreme cases, protein is also utilized.
3.3.10	Discuss the characteristics of the three energy systems and their relative contributions during exercise.	3	Limit to: • fuel sources • duration • intensity • amount of ATP production and by-products.
3.3.11	Evaluate the relative contributions of the three energy systems during different types of exercise.	3	Energy continuum. Different types of exercise (endurance athlete, games player, sprinter) should be considered.

Topic 4: Movement analysis (15 hours)

4.1 Neuromuscular function

4 hours

	Assessment statement	Obj	Teacher's notes
4.1.1	Label a diagram of a motor unit.	1	Limit to: • dendrite • cell body • nucleus • axon • motor end plate • synapse • muscle.
4.1.2	Explain the role of neurotransmitters in stimulating skeletal muscle contraction.	3	Limit to acetylcholine and cholinesterase.
4.1.3	Explain how skeletal muscle contracts by the sliding filament theory.	3	Include the terms: • myofibril • myofilament • sarcomere • actin • myosin • H zone • A band • Z line • tropomyosin • troponin • sarcoplasmic reticulum • calcium ions • ATP. **Aim 7:** Various online muscle contraction simulations are available.
4.1.4	Explain how slow and fast twitch fibre types differ in structure and function.	3	Limit fibre types to slow twitch (type I) and fast twitch (type IIa and type IIb). Type IIa and IIb are high in glycogen content depending on training status. **Aim 8:** Implications of invasive techniques for taking samples, such as muscle biopsies. **Aim 9:** Implications of drawing conclusions from indirect measurements.

4.2 Joint and movement type

3 hours

	Assessment statement	Obj	Teacher's notes
4.2.1	Outline the types of movement of synovial joints.	2	Consider: • flexion • extension • abduction • adduction • pronation • supination • elevation • depression • rotation • circumduction • dorsi flexion • plantar flexion • eversion • inversion.
4.2.2	Outline the types of muscle contraction.	2	Consider: • isotonic • isometric • isokinetic • concentric • eccentric.
4.2.3	Explain the concept of reciprocal inhibition.	3	Consider agonist and antagonist.
4.2.4	Analyse movements in relation to joint action and muscle contraction.	3	For example, during the upward motion of a bicep curl the joint action is flexion. The bicep contracts concentrically while the tricep relaxes eccentrically.
4.2.5	Explain delayed onset muscle soreness (DOMS) in relation to eccentric and concentric muscle contractions.	3	DOMS results primarily from eccentric muscle action and is associated with structural muscle damage, inflammatory reactions in the muscle, overstretching and overtraining. DOMS is prevented/minimized by reducing the eccentric component of muscle actions during early training, starting training at a low intensity and gradually increasing the intensity, and warming up before exercise, cooling down after exercise.

4.3 Fundamentals of biomechanics

8 hours

In this sub-topic, no calculations are required.

	Assessment statement	Obj	Teacher's notes
4.3.1	Define the terms *force*, *speed*, *velocity*, *displacement*, *acceleration*, *momentum* and *impulse*.	1	Encourage the use of vectors and scalars.
4.3.2	Analyse velocity–time, distance–time and force–time graphs of sporting actions.	3	
4.3.3	Define the term *centre of mass*.	1	
4.3.4	Explain that a change in body position during sporting activities can change the position of the centre of mass.	3	Consider one example of an activity where the centre of mass remains within the body throughout the movement and one activity where the centre of mass temporarily lies outside the body. Students should understand the changes in body position and centre of mass pathway.
4.3.5	Distinguish between *first*, *second* and *third class levers*.	2	
4.3.6	Label anatomical representations of levers.	1	Limit to: • the triceps–elbow joint • the calf–ankle joint • the biceps–elbow joint. Students will be expected to indicate effort, load, fulcrum and the muscles and bones involved.
4.3.7	Define Newton's three laws of motion.	1	
4.3.8	Explain how Newton's three laws of motion apply to sporting activities.	3	For example, consider how Newton's second and third laws enable an athlete to accelerate out of starting blocks. Impulse momentum relationship. The law of conservation of momentum should also be considered.
4.3.9	State the relationship between angular momentum, moment of inertia and angular velocity.	1	
4.3.10	Explain the concept of angular momentum in relation to sporting activities.	3	Include consideration of moments of inertia, major axes of rotation and an appreciation of the law of conservation of angular momentum.

	Assessment statement	Obj	Teacher's notes
4.3.11	Explain the factors that affect projectile motion at take-off or release.	3	Include speed of release, height of release and angle of release.
4.3.12	Outline the Bernoulli principle with respect to projectile motion in sporting activities.	2	The relationship between airflow velocity and air pressure is an inverse one, and is expressed in Bernoulli's principle. The pressure difference causes the spinning golf ball to experience a force directed from the region of high air pressure to the region of low air pressure. A golf ball with backspin will experience higher air pressure on the bottom of the ball and lower air pressure on the top of the ball, causing a lift force (from high air pressure to low air pressure). Consider how airflow affects the golf ball and one other example. When an object is moving through the air it is important to consider the relative airflow on different sides of the object. The airflow difference between opposite sides (for example, the bottom and top of a spinning golf ball) of the object moving through the air causes a pressure difference between the two sides. The lift force is perpendicular to the direction of the airflow. **Aim 7:** Still photography and video can be used to record and analyse movement. A visit to a university may be possible to see the use of high-speed photography, photoelectric cells and motion-analysis software.

Topic 5: Skill in sports (15 hours)

5.1 The characteristics and classification of skill

4 hours

	Assessment statement	Obj	Teacher's notes
5.1.1	Define the term *skill*.	1	Skill is the consistent production of goal-oriented movements, which are learned and specific to the task (McMorris 2004).
5.1.2	Describe the different types of skill.	2	Limit to cognitive, perceptual, motor and perceptual motor skills.
5.1.3	Outline the different approaches to classifying motor skills.	2	Limit to: • gross–fine • open–closed • discrete–serial–continuous • external–internal paced skills • interaction continuum (individual–coactive–interactive).
5.1.4.	Compare skill profiles for contrasting sports.	3	Using the continua in 5.1.3, compare contrasting sports.
5.1.5	Outline ability.	2	*Ability* refers to a general trait or capacity of the individual that is related to the performance and performance potential of a variety of skills or tasks. **TOK:** Abilities have been thought of as stable traits but a more modern perspective understands that people have a genetic potential for each ability and that their level of performance in a particular ability can be influenced by a number of factors such as life experience or coaching. **TOK:** Current research considers that abilities will change with time.
5.1.6	Distinguish between Fleishman's *physical proficiency abilities* (physical factors) and *perceptual motor abilities* (psychomotor factors).	2	Fleishman (1972) distinguishes between physical proficiency and perceptual motor ability. Recall of the individual abilities is not required.
5.1.7	Define the term *technique*.	1	In general terms, technique is a "way of doing". In the performance of a specific sports skill it is defined as the "way in which that sports skill is performed".

	Assessment statement	Obj	Teacher's notes
5.1.8	State the relationship between ability, skill and technique.	1	Skill = ability + selection of an appropriate technique.
5.1.9	Discuss the differences between a skilled and a novice performer.	3	Limit to consistency, accuracy, control, learned, efficiency, goal-directed and fluency.

5.2 Information processing

6 hours

	Assessment statement	Obj	Teacher's notes
5.2.1	Describe a simple model of information processing.	2	Information processing is the system by which we take information from our surrounding environment, use it to make a decision and then produce a response: input–decision-making–output. All the approaches are only models. Input and output are assessable/observable, but the decision-making process can only be speculation.
5.2.2	Describe Welford's model of information processing.	2	Welford's model (1968) includes: • sense organs • perception • short-term memory • long-term memory • decision-making • effector control • feedback.
5.2.3	Outline the components associated with sensory input.	2	Consider exteroceptors, proprioceptors and interoceptors.
5.2.4	Explain the signal-detection process.	3	Often referred to as the detection–comparison–recognition process (DCR). Limit to background noise, intensity of the stimulus, efficiency of the sense organs, early signal detection and improving signal detection.
5.2.5	Distinguish between the characteristics of *short-term sensory store*, *short-term memory* and *long-term memory*.	2	Limit to capacity, duration and retrieval.

	Assessment statement	Obj	Teacher's notes
5.2.6	Discuss the relationship between selective attention and memory.	3	Selective attention (SA) operates in the short-term sensory store (STSS). Only the relevant information is passed to the short-term memory (STM) where it is held for several seconds. SA ensures that information overload does not occur and prevents confusion, as the brain would not be able to cope with streams of information. A filtering mechanism operates, which separates the relevant information from the irrelevant (noise) information so that athletes concentrate on one cue or stimulus (for example, the ball, position of player in a game of tennis) to the exclusion of others. SA is very important when accuracy or fast responses are required and can be improved by learning through past experience and interaction with long-term memory.
5.2.7	Compare different methods of memory improvement.	3	Limit to: • rehearsal • coding • brevity • clarity • chunking • organization • association • practice.
5.2.8	Define the term *response time*.	1	Response time = reaction time + movement time. **Aim 7:** Use of online methods of measuring response time.
5.2.9	Outline factors that determine response time.	2	Response time is an ability, having individual and group variance (for example, gender and age). Reaction time includes stimulus transmission, detection, recognition, decision to respond, nerve transmission time and initiation of action. Include consideration of Hick's Law.
5.2.10	Evaluate the concept of the psychological refractory period (PRP).	3	Include the single channel mechanism and how PRP helps to explain deception in sports.

	Assessment statement	Obj	Teacher's notes
5.2.11	Describe a motor programme.	2	Defined as a set of movements stored as a whole in the memory, regardless of whether feedback is used in their execution. Limit to: • a whole plan (executive programme/motor programme) and subroutines • coordination of subroutines • relegating executive programmes to subroutines.
5.2.12	Compare motor programmes from both open- and closed-loop perspectives.	3	Include Adams' concepts of memory trace and perceptual trace.
5.2.13	Outline the role of feedback in information-processing models.	2	Limit to: • intrinsic, extrinsic • knowledge of results, knowledge of performance • positive, negative • concurrent, terminal.
5.2.14	Outline the role of feedback with the learning process.	2	Limit to: • reinforcement of learning • motivation • adaptation of performance • punishment.

5.3 Principles of skill learning

5 hours

	Assessment statement	Obj	Teacher's notes
5.3.1	Distinguish between *learning* and *performance*.	2	Learning is a relatively permanent change in performance brought about by experience, excluding changes due to maturation and degeneration. Performance is a temporary occurrence, fluctuating over time. A change in performance over time is often used to infer learning.
5.3.2	Describe the phases (stages) of learning.	2	Cognitive/verbal (early phase), associative/motor (intermediate phase) and autonomous (final phase).

	Assessment statement	Obj	Teacher's notes
5.3.3	Outline the different types of learning curves.	2	Limit to: • positive acceleration • negative acceleration • linear • plateau.
5.3.4	Discuss factors that contribute to the different rates of learning.	3	Limit to: • physical maturation • physical fitness • individual differences of coaches • age • difficulty of task • teaching environment • motivation.
5.3.5	Define the concept of *transfer*.	1	
5.3.6	Outline the types of transfer.	2	Limit to positive and negative, as they apply to: • skill to skill • practice to performance • abilities to skills • bilateral • stage to stage • principles to skills. Refer to an example in each case.
5.3.7	Outline the different types of practice.	2	Limit to • distributed • massed • fixed (drill) • variable • mental.
5.3.8	Explain the different types of presentation.	3	Limit to: • whole • whole–part–whole • progressive part • part. Refer to an example in each case.
5.3.9	Outline the spectrum of teaching styles.	2	Limit to command, reciprocal and problem-solving.

Topic 6: Measurement and evaluation of human performance (13 hours)

6.1 Statistical analysis

2 hours

	Assessment statement	Obj	Teacher's notes
6.1.1	Outline that error bars are a graphical representation of the variability of data.	2	Only standard deviation needs to be considered.
6.1.2	Calculate the mean and standard deviation of a set of values.	2	Students should specify the sample standard deviation, not the population standard deviation. Students will not be expected to know the formulas for calculating these statistics. They will be expected to use the statistics function of a graphic display or scientific calculator. **Aim 7:** Students could also be taught how to calculate standard deviation using a spreadsheet computer program.
6.1.3	State that the statistic standard deviation is used to summarize the spread of values around the mean, and that within a normal distribution approximately 68% and 95% of the values fall within plus or minus one or two standard deviations respectively.	1	For normally distributed data, about 68% of all values lie within ±1 standard deviation of the mean. This rises to about 95% for ±2 standard deviations.
6.1.4	Explain how the standard deviation is useful for comparing the means and the spread of data between two or more samples.	3	A small standard deviation indicates that the data is clustered closely around the mean value. Conversely, a large standard deviation indicates a wider spread around the mean.
6.1.5	Outline the meaning of coefficient of variation.	2	Coefficient of variation is the ratio of the standard deviation to the mean expressed as a percentage.

	Assessment statement	Obj	Teacher's notes
6.1.6	Deduce the significance of the difference between two sets of data using calculated values for *t* and the appropriate tables.	3	For the *t*-test to be applied, ideally the data should have a normal distribution and a sample size of at least 10. The *t*-test can be used to compare two sets of data and measure the amount of overlap. Students will not be expected to calculate values of *t*. Only two-tailed, paired and unpaired *t*-tests are expected. **Aim 7:** While students are not expected to calculate a value for the *t*-test, students could be shown how to calculate such values using a spreadsheet program or the graphic display calculator. **TOK:** The scientific community defines an objective standard by which claims about data can be made.
6.1.7	Explain that the existence of a correlation does not establish that there is a causal relationship between two variables.	3	**Aim 7:** While calculations of such values are not expected, students who want to use *r* and r^2 values in their practical work could be shown how to determine such values using a spreadsheet program.

6.2 Study design

4 hours

	Assessment statement	Obj	Teacher's notes
6.2.1	Outline the importance of specificity, accuracy, reliability and validity with regard to fitness testing.	2	
6.2.2	Discuss the importance of study design in the context of the sports, exercise and health sciences.	3	This should include a demonstration of causality in experimental results by the inclusion of control groups, randomization, placebos, blinding and double-blinding, statistical analysis.
6.2.3	Outline the importance of the Physical Activity Readiness Questionnaire (PAR-Q).	2	
6.2.4	Evaluate field, laboratory, sub-maximal and maximal tests of human performance.	3	

6.3 Components of fitness

4 hours

	Assessment statement	Obj	Teacher's notes
6.3.1	Distinguish between the concepts of *health-related fitness* and *performance-related (skill-related) fitness*.	2	*Health-related fitness* includes body composition, cardio-respiratory fitness (aerobic capacity), flexibility, muscular endurance, strength. *Performance-related (skill-related) fitness* includes agility, balance, coordination, power, reaction time and speed. Some components of performance-related fitness (agility, balance, coordination) could become health-related for certain groups such as the elderly and those suffering from hypokinetic diseases.
6.3.2	Outline the major components of fitness identified in 6.3.1.	2	
6.3.3	Outline and evaluate a variety of fitness tests.	3	Consider validity, reliability and limitations of the following tests. • Aerobic capacity—multistage fitness test/ bleep test (Leger test), Cooper's 12-minute run, Harvard step test • Flexibility—sit and reach • Muscle endurance—maximum sit-ups, maximum push-ups, flexed arm hang • Agility—Illinois agility test • Strength—hand grip dynamometer • Speed—40-metre sprint • Body composition—body mass index, anthropometry and underwater weighing • Balance—stork stand • Coordination—hand ball toss • Reaction time—drop test, computer simulation • Power—vertical jump, standing broad jump **Aim 9:** Issues of using direct and indirect measures of fitness, and the extrapolation of data and generalizations across populations, could be considered. Cultural variations in the establishment of standardized norms may also be explored. **Aim 7:** Opportunity to use computer simulation/ modelling and databases.

6.4 Principles of training programme design

3 hours

	Assessment statement	Obj	Teacher's notes
6.4.1	Describe the essential elements of a general training programme.	2	This should include: • warm-up and stretching activities • endurance training • cool down and stretching activities • flexibility training • resistance training • the incorporation of recreational activities and sports into the schedule. **TOK:** Recent research questions the effectiveness of static stretching as a necessary component of the warm-up. The difficulty of conducting controlled trials without a placebo effect could be discussed. The willingness of athletes to believe what they are told, without questioning the advice, could also be considered.
6.4.2	Discuss the key principles of training programme design.	3	Limit to: • progression • overload (frequency, intensity and duration) • specificity • reversibility • variety • periodization.
6.4.3	Outline ways in which exercise intensity can be monitored.	2	Limit to: • use of heart rate based upon its relationship with oxygen uptake, that is, target heart rate that coincides with a given percentage of maximal oxygen uptake • the Karvonen method • the training heart rate range/zone • ratings of perceived exertion (Borg/OMNI/CERT scale).

Syllabus content—AHL

Topic 7: Further anatomy (7 hours)

TOK: Classical anatomical studies separate the human body into discrete systems. To what extent can separating components give us knowledge of the whole?

7.1 The skin system

2 hours

	Assessment statement	Obj	Teacher's notes
7.1.1	Annotate a diagram of the generalized structure of the skin.	2	Include: • epidermis • dermis • fat • glands • hair follicles.
7.1.2	Describe the functions of the skin.	2	Include: • regulation of body temperature • protection and immunity • sensation • excretion • synthesis of vitamin D.

7.2 Structure and function of the brain

5 hours

	Assessment statement	Obj	Teacher's notes
7.2.1	Label the location of the principal structures of the brain.	1	Limit to: • the brain stem • the diencephalon • the two hemispheres of the cerebrum • the cerebellum.
7.2.2	Label the location of the principal lobes of the cerebrum.	1	Limit to: • frontal lobe • parietal lobe • occipital lobe • temporal lobe • limbic lobe.

	Assessment statement	Obj	Teacher's notes
7.2.3	Outline blood supply to the brain.	2	Include: • the major arteries • brachiocephalic trunk (right and left common carotid artery) • right and left internal and external carotid artery • the blood-brain barrier.
7.2.4	Describe the principal source of energy for brain cells.	2	The brain obtains energy using glucose and oxygen, which pass rapidly from the blood to the brain cells. Glucose and oxygen are used to make ATP inside the brain by the process of aerobic respiration. Carbohydrate storage in the brain is limited, so the supply of glucose must be continuous. If blood entering the brain has low glucose or oxygen levels, mental confusion, dizziness, convulsions, and loss of consciousness may occur.
7.2.5	Explain the function of the principal parts of the brain.	3	Include brain stem, diencephalon, cerebrum and cerebellum. • **Brain stem—**respiratory and cardiovascular control centres. • Diencephalon – Thalamus—perception of sensations (pain, temperature, pressure); cognition. – Hypothalamus—control of autonomic nervous system (ANS), heart rate and blood pressure, pituitary gland, body temperature, appetite, thirst, fluid and electrolyte balance, circadian rhythms. • **Link to topic 8:** The endocrine system, pineal gland. • **Cerebrum—**responsible for high-level brain functions such as thinking, language and emotion, and motivation. The function is divided into three broad processes. 1. sensory (receiving sensory impulses) 2. association (interpreting and storing input, and initiating a response) 3. motor (transmitting impulses to effectors).

	Assessment statement	Obj	Teacher's notes
			Although the lobes do not function independently, each lobe is associated with certain aspects of the following processes. • **Frontal lobe**—many aspects of association such as reasoning and motivation, planning, emotions and problem-solving. Also contains the speech and movement motor areas. • **Parietal lobe**—somatic sensory and motor areas linked to movement, body awareness, orientation and navigation. Also contains symbolic and speech association areas. • **Occipital lobe**—visual sensory and association centre. • **Temporal lobe**—auditory sensory and association area; many aspects of long-term and visual memory. • **Limbic lobe** concerned with association processes such as emotion, behaviour, motivation and long-term memory. **Cerebellum** • Helps to smooth and coordinate sequences of skeletal muscle contractions. • Regulates posture and balance. • Makes possible all skilled motor activities, from catching a ball to dancing.

Topic 8: The endocrine system (7 hours)

Aim 8: Consider the ethical aspects of using synthetic hormones to enhance sports performance.

TOK: Understanding the endocrine system relies on the use of complex technical vocabulary. How important is it that there is one scientific language?

	Assessment statement	Obj	Teacher's notes
8.1.1	Label the location of the major endocrine organs in the human body.	1	Limit to: • hypothalamus • pituitary gland • pineal gland • thyroid gland • adrenal glands • pancreas • ovaries and testes.
8.1.2	Describe the role of circulating (blood) and local hormones.	2	Hormones are secreted by endocrine glands to regulate and coordinate a range of bodily functions. Release of most hormones occurs in short bursts, although some are secreted over longer periods of time in order to stimulate permanent changes to the body. Hormones affect only specific target cells by (chemically) binding to specific receptors. Circulating hormones travel around the body in the blood. Examples include adrenaline and testosterone. Local hormones act on neighbouring cells without entering the bloodstream and are usually inactivated quickly. Examples include glucagon and serotonin.
8.1.3	Explain how circulating hormone levels are regulated.	3	They are regulated by complex feedback loops that may be influenced by: • signals from the nervous system, such as adrenaline • chemical changes in the blood, such as insulin • other hormones, such as growth hormone.

	Assessment statement	Obj	Teacher's notes
8.1.4	Explain the relationship between the hypothalamus and the pituitary gland.	3	The hypothalamus and the pituitary gland are together responsible for homeostasis. • The hypothalamus is the part of the brain that controls the pituitary gland. • The pituitary gland is an endocrine gland located in the brain below the hypothalamus. • Neurohormones, such as GHRH and somatostatin from the hypothalamus, directly influence the pituitary gland. • Nerve impulses from the hypothalamus also stimulate the pituitary gland. The pituitary gland secretes hormones, such as Antidiuretic hormone (ADH) and growth hormone (GH), that help regulate a wide range of bodily functions including growth, and water and temperature regulation.

Topic 9: Fatigue (6 hours)

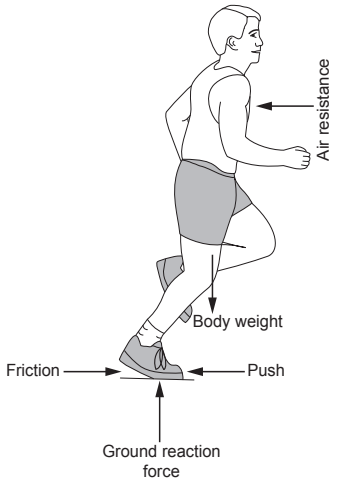
	Assessment statement	Obj	Teacher's notes
9.1.1	Define *fatigue* in sports.	1	A reversible, exercise-induced decline in performance.
9.1.2	Outline the different types of fatigue.	2	Limit to: • peripheral fatigue—develops rapidly and is caused by reduced muscle cell force • central (or mental) fatigue—develops during prolonged exercise and is caused by impaired function of the central nervous system.
9.1.3	Distinguish between *high-intensity* and *endurance* activities.	2	High-intensity exercise involves a vigorous bout of intense activity that may last for less than a second, or as long as 1–2 minutes, for example, some types of interval training, plyometrics. The major sources of energy for this are derived from anaerobic processes. Endurance activities involve prolonged sessions of low-intensity activity that may last from several minutes to several hours, for example, leisure cycling or jogging. The major sources of energy for endurance activities are aerobic processes.
9.1.4	Discuss causes of fatigue in different types of activity or exercise.	3	Fatigue is perceived differently by individual athletes and may depend on multiple factors such as age, level of fitness and the specific type of activity or exercise carried out. On a physiological level, the development of peripheral fatigue in **high-intensity** activities depends on the rate of: • depletion of energy sources (creatine phosphate and ATP) • increase in levels of the products of exercise such as lactate and hydrogen ions. The physiological causes of peripheral fatigue in **endurance** activities include: • depletion of muscle and liver glycogen reserves • reduction in Ca^{2+} release • depletion of acetylcholine • dehydration • electrolyte loss • overheating. Central (mental) fatigue is a significant factor in many endurance sports caused by failure of neural transmission.

	Assessment statement	Obj	Teacher's notes
9.1.5	Discuss recovery from fatigue after sports.	3	Different aspects of recovery can occur at different rates, and recovery rate also depends on the type of activity (high-intensity, team sports or endurance). Include: • excess post-exercise oxygen consumption (EPOC) for: – restoration of muscle creatine phosphate stores – removal of lactic acid – replenishment of myoglobin stores • replacement of muscle and liver glycogen stores. **Link to option A:** Optimizing physiological performance **TOK:** How are our perceptions of fatigue and recovery influenced by different ways of knowing?

Topic 10: Friction and drag (8 hours)

	Assessment statement	Obj	Teacher's notes
10.1.1	Describe friction.	2	A force that acts parallel to the interface of two surfaces that are in contact, and opposes their relative motion. The value of the force of friction, F_f is calculated using: $$F_f = \mu R$$ Where μ is the coefficient of friction and R is the normal reaction force.
10.1.2	Describe the coefficient of friction.	2	The **coefficient of friction** (COF, μ) is a dimensionless scalar quantity which is the ratio of the force of friction, F_f between two bodies and the normal reaction force, R. $$\mu = \frac{F_f}{R}$$ The magnitude of the coefficient of friction depends on the materials in contact: steel on ice (in ice skating) has a low coefficient of friction; rubber sole on the ground (running) has a high coefficient of friction. The greater the interaction between the molecules of the interfacing surfaces, the greater the size of the coefficient of friction. Coefficients of friction range in value between zero and one, but can sometimes be higher.
10.1.3	Distinguish between the coefficient of *static friction* and *dynamic friction*.	2	When a force is applied to attempt to move a stationary object over another surface, we consider the coefficient of static friction. At some point, the force applied is sufficient to overcome the static friction and the object will begin to move. Once the object is in motion, we consider the coefficient of dynamic friction. The coefficient of dynamic friction is usually lower than the coefficient of static friction.

	Assessment statement	Obj	Teacher's notes
10.1.4	Explain the influence of friction on sports performance.	3	Consider maximizing and minimizing frictional influences in order to enhance performance. For example: • sports shoes (including spikes/cleats) and playing surface (grass, artificial surfaces, wood) • winter sports (skiing, ice skating) • use of a golf glove • cycling on an indoor sloping velodrome.
10.1.5	Define *drag*.	1	Drag is the force or forces acting to oppose the motion of an object through a fluid medium such as air or water.
10.1.6	Outline different types of drag that can be found in a variety of sporting environments.	2	Limit to: • surface drag: As a body moves through a fluid, its outer surface catches a layer of the fluid nearby, slowing it down compared to the fluid further away and so causing drag. This can be minimized by changing the surface to reduce the interaction between surface and fluid. Example: The use of shark-skin suits in swimming or shaving the swimmer's body to make it smooth. • form drag: As a body pushes against a fluid, the fluid pushes back (action and reaction). By streamlining the body and minimizing the surface area facing the direction of the motion, this type of drag is reduced. Example: Cyclists adopting a low profile position. • wave drag: When a body moves along the surface of a fluid (usually water) some fluid is displaced to form a wave. These waves cause additional forces that oppose motion. Wave drag can be reduced by avoiding motion at the interface between air and water. Example: Swimming underwater for as long as is allowed at the start of a race.

	Assessment statement	Obj	Teacher's notes
10.1.7	Discuss factors that influence the amount of drag in sports.	3	Consider the influence of fluid viscosity, surface size, shape, texture and relative velocity on drag. For example: • clothing for skiers, swimmers, runners, cyclists and base jumpers • equipment for cycling (helmet and bicycle design) • body position for a speed skater and swimmer. Drag increases dramatically with speed. (It increases as the square of the speed.) **Aim 8:** Consider the economic implications of developing technologies to improve performance in sports. **Int:** Consider the availability of performance-enhancing technologies in different parts of the world.
10.1.8	Annotate a free-body diagram showing the direction of relevant forces acting on an athlete or object in sports.	2	

Topic 11: Skill acquisition and analysis (9 hours)

11.1 Pedagogy for skill acquisition

4 hours

	Assessment statement	Obj	Teacher's notes
11.1.1	Distinguish between *traditional* and *non-linear pedagogy* in sports.	2	Traditional pedagogy occurs through the simple transmission of fixed knowledge from coach to athlete. Features of this approach are: • content-focused learning • coach-led learning • coach has full responsibility for what, how and when learning takes place. Non-linear pedagogy occurs in a non-linear, unpredictable manner with coach and athletes exploring a situation/problem/issue together. Features of this approach are: • high levels of connectivity between athletes and coaches • process-orientated learning • development of creative processes in athletes.

	Assessment statement	Obj	Teacher's notes
11.1.2	Discuss Newell's (1986) constraints-led approach to teaching motor skills in physical education.	3	Motor learning is viewed as an ongoing dynamic, non-linear process, influenced by various constraints. Constraints are classified into three categories. 1. Athlete constraints 2. Environmental constraints 3. Task constraints Athlete constraints include: • self-organization • movement patterns • cognition • decision-making. Environmental constraints include: • physical factors such as gravity, altitude, light, music or noise as well as floor space, court surface and net or lines on the area of play • social factors, such as peer pressure, social and cultural expectations. Task constraints include: • the goal of the specific task • rules on actions or conditions on tasks • rules on the equipment used. Examples of ways that coaches can manipulate constraints include: • modifying equipment available • modifying the size of playing areas • setting relevant task goals in games • choosing beat/tempo in dance • suggesting imagery ideas • enforcing specific rules/conditions for performance.

	Assessment statement	Obj	Teacher's notes
11.1.3	Suggest how a constraints-led approach to learning a given sport can influence motivation.	3	The impact of a constraints-led approach may be different for individual athletes. Examples of how it can be used include the following. • Athlete: Minimize the number of rules. For example, in touch rugby, allow forward passes. • Environment: Limit the space available to participants. For example, in netball, have attackers and defenders in specific zones so that players focus on their own tasks. • Task: Modify the equipment so that the activity allows for more success. For example, increase the size of the golf ball (use a tennis ball) and the size of the golf club. Such approaches might influence the motivation of the athlete in the short term and can have longer-term consequences for the evolution of talent. **Link to option B:** Psychology of sports, topic 5.

11.2 Notation and analysis

5 hours

	Assessment statement	Obj	Teacher's notes
11.2.1	Outline the reasons for using notational analysis in physical education and sports.	2	It is primarily used to inform the coaching process, and so improve athlete performance through: • providing an objective way of recording performance • quantifying performance in a consistent and reliable manner • facilitating quantitative and qualitative feedback.
11.2.2	List five applications of notation in physical education and sporting contexts.	1	1. Tactical evaluation 2. Technical evaluation 3. Analysis of movement 4. Development of databases and models 5. Educational use with teacher/coach and athlete

	Assessment statement	Obj	Teacher's notes
11.2.3	Distinguish between a *phase analysis model* and *performance outcome model* of qualitative biomechanical analysis for an **individual** sports technique.	2	Limit to the following. • Phase analysis model (sequential, based on movement principles) – Preparation – Retraction – Action – Follow-through • Performance outcome model (hierarchical, based on mechanical relationships underpinning performance) – Speed principles – Force principles – Coordination principles – Specific performance principles
11.2.4	Explain how a flow chart system can be used for match analysis in a team invasion game.	3	Consider flow charts that identify features such as: • the player who has possession • the location (in the field of play) for a change in possession • the player who gains possession • the method of change in possession (for example, tackle or interception).
11.2.5	Suggest how to develop a simple notation system for team games.	3	Limit to: • scattergrams • frequency tables • sequential systems.
11.2.6	Outline three examples of the use of digital technology in sports analysis.	2	Limit to: • motion tracking and capture devices (for example, Hawkeye, Dartfish) • performance-analysis software (for example, Prozone) • nutrition, fitness and training analysis software (for example, Bodybyte).

	Assessment statement	Obj	Teacher's notes
11.2.7	Evaluate the use of information technologies in sports analysis for different sports contexts.	3	• Provides data not available through traditional analysis techniques (for example, power output measurements in cycling). • Provides data over shorter or longer timescales (for example. tracking of ball trajectories during pitching/throwing). • Data is objective and accurate. • Processed data improves visualization and allows image comparison. • Feedback is immediate and efficient. • Feedback information is manageable and is specifically adjusted for individual needs. • Many new software technologies are relatively inexpensive. • Coaches need training to make effective use of, and to develop skill in, interpretation of data. • Limited availability in many regions. • Limited use in all situations, for example. during matches or in remote locations. • May lead to over-reliance on objective data. **Aim 8:** Raising awareness of the use of technology. **TOK:** The use of digital technologies can have a significant impact on skill acquisition. How do changes in technology influence ethical choices in sports?

Topic 12: Genetics and athletic performance (7 hours)

	Assessment statement	Obj	Teacher's notes
12.1.1	Outline the role of genes in the inheritance of human characteristics.	2	Limit to the following. • Chromosomes are mainly made of deoxyribonucleic acid (DNA), sections of which are referred to as **genes**. • DNA undergoes replication as part of cell division to pass on the genes to new cells. • Children inherit genes from their parents via the sex cells (gametes), with 50% from the mother and 50% from the father. Many millions of different combinations of these genes from the same parents are possible. • Human characteristics (or phenotype) are determined by their genes (the genotype). • Some characteristics are expressed developmentally by genes (for example, eye colour, gender), others also require an environmental switch (for example, height, VO_2max). Note: Students are not expected to know the structure of DNA, the mechanism of replication, or the details of meiosis.
12.1.2	Outline how genes can influence human characteristics.	2	Limit to the following. • Genes code for the production of proteins, which are responsible for the development of an individual. • Genes can be switched on or switched off depending on internal or external factors, so that characteristics influencing athletic performance can change during a person's lifetime. • Multiple genes determine the measurable heritable characteristics for each individual so it is highly unlikely that a single or even a few genetic elements are associated with superior athletic performance. Note: Students are not expected to know the mechanisms of transcription or regulation of gene expression.

	Assessment statement	Obj	Teacher's notes
12.1.3	Discuss the relative contribution of genetic and environmental factors on performance in different sports.	3	Characteristics that are influenced by genetics include height, muscle fibre type, anaerobic threshold, lung capacity and flexibility. Environmental factors that also influence performance include physical training, nutrition, technological aids and climate. Training maximizes the likelihood of obtaining a performance level with a genetically controlled ceiling. Elite athletes can be distinguished from less well-performing athletes with respect to both inherited (genetic) characteristics and training histories. It is presently not possible to ascertain the relative contribution of genetics or training to elite sporting performance, and this contribution is likely to differ for different sports. **TOK:** Both environmental and genetic factors influence sporting performance. When two areas of knowledge are linked, how can we decide which has more relevance? **Aim 8:** Studies on twins have provided much scientific knowledge about the "nature versus nurture" debate, but are such studies morally acceptable?
12.1.4	Discuss the implications of genetic screening for sports, exercise and health.	3	Consider: • the identification of life-threatening conditions such as risk of sudden cardiac death, connective tissue disorder • the potential to predict susceptibility to injury and so reduce risk/improve safety for an individual athlete • ethical implications of involuntary exclusion from, or discrimination in, one or more sports • ethical implications of discrimination beyond sport, for example, in employment • the possibility of gene doping in the future to improve athletic performance. **Link to option B:** Psychology of sports: Talent identification and development **TOK:** Genetic screening has implications for competitive sports and public health in general. Are there areas of scientific knowledge that are morally unacceptable?

Topic 13: Exercise and immunity (6 hours)

	Assessment statement	Obj	Teacher's notes
13.1.1	State the function of the immune system.	1	The immune system protects the body from infectious disease. It is involved in tissue repair and protection against potential pathogens.
13.1.2	Outline the mechanisms the body uses in response to damage or an infectious agent.	2	Limit to the following. • Physical: skin, epithelial linings, mucosal secretions • Chemical: pH of bodily fluids, hormones and other soluble factors • Leucocytes: white blood cells that fight disease • Inflammation • Clotting • Lymphocyte and antibody production
13.1.3	Describe the effects of intense and long-term training on the immune system.	2	An intense bout of exercise can cause tissue damage and so is accompanied by responses that are similar to those of an infection, such as: • increase in leucocytes (dependent on the duration and intensity of exercise) • inflammation. When training loads are high **and** prolonged, there tends to be a decrease in innate and adaptive immune function. • Sustained increases in levels of cortisol and adrenaline over long periods suppress the immune system. Leucocyte numbers drop compared to sedentary people.

	Assessment statement	Obj	Teacher's notes
13.1.4	Discuss the relationship between exercise and susceptibility to infection.	3	Athletes are more susceptible to infections than their sedentary peers because of: • lower leucocyte numbers caused by the stress of the exercise • inflammation caused by muscle damage • greater exposure to airborne bacteria and viruses because of an increased rate and depth of breathing. The relationship between exercise intensity and susceptibility to disease can be seen as a J curve because an elite athlete has not only to be physically fit but also have an immune system able to withstand infections, even during severe physiological and psychological stress. Moderate exercise, however, is associated with reduced susceptibility to infection.
13.1.5	Describe strategies for minimizing risk from infection among athletes.	2	• Incorporation of sufficient recovery time into training programmes. • Avoid close contact with people with infections. • Maintain oral hygiene. • Maintain hydration status. • Ensure water is pathogen-free. • Maintain good personal hygiene (for example, washing hands, avoiding hand-to mouth contact). • Maintain a suitable and varied diet. • Ensure sufficient sleep. **TOK:** Knowledge about infectious diseases is gained through scientific research. What constitutes an allowable level of risk for humans involved in this research?

Syllabus content—Options

Option A: Optimizing physiological performance (15 hours SL, 25 hours HL)

A.1 Training

5 hours

	Assessment statement	Obj	Teacher's notes
A.1.1	Distinguish between *training*, *overtraining* and *overreaching*.	2	Training is performing exercise in an organized manner on a regular basis with a specific goal in mind (cross-reference with 6.2). Overtraining is when an athlete attempts to do more training than he or she is able to physically and/or mentally tolerate. Overtraining results in a number of symptoms that are highly individualized. Overreaching is transient overtraining.
A.1.2	Describe various methods of training.	2	Limit to: • flexibility training • strength and resistance training • circuit training • interval training • plyometrics • continuous training • fartlek training/speed play • cross-training.
A.1.3	Discuss possible indicators of overtraining.	3	Limit to: • changes to resting heart rate • chronic muscle soreness • reduced immune function and frequent upper-respiratory tract infections (coughs and colds) • sleep disturbance • fatigue • decreased appetite • sudden and unexplained decrease in performance.

	Assessment statement	Obj	Teacher's notes
A.1.4	Discuss how periodization should be organized to optimize performance and avoid overtraining and injury.	3	Periodization—transition (post-season), preparation (pre-season), competition. Knowledge of macrocycle, mesocycle and microcycle **is** required.

A.2 Environmental factors and physical performance

6 hours

	Assessment statement	Obj	Teacher's notes
A.2.1	Explain the relationship between cellular metabolism and the production of heat in the human body.	3	Include consideration of the meaning of efficiency with regard to energy liberation, ATP re-synthesis and heat production.
A.2.2	State the normal physiological range for core body temperature.	1	
A.2.3	Outline how the body thermoregulates in hot and cold environments.	2	Include the principles of conduction, convection, radiation and evaporation. **Int:** The ability of people who habitually live in very cold/hot climates to tolerate these harsh conditions compared with people who live in temperate climates could be considered.
A.2.4	Discuss the significance of humidity and wind in relation to body heat loss.	3	
A.2.5	Describe the formation of sweat and the sweat response.	2	Consideration of the role of the sympathetic nervous system and the hypothalamus is not required.
A.2.6	Discuss the physiological responses that occur during prolonged exercise in the heat.	3	Limit this to cardiovascular response (cross-reference with topic 2.2.8), energy metabolism* and sweating. * The reduced muscle blood flow in high temperatures results in increased glycogen breakdown in the muscle and higher levels of muscle and blood lactate in comparison to the same exercise performed in a cooler environment.
A.2.7	Discuss the health risks associated with exercising in the heat.	3	Heat-related disorders include heat cramps, heat exhaustion and heat stroke. Because of their relatively large body surface area and immature sweat response, infants, children and young adolescents are more susceptible to complications associated with exercise performed in the heat and the cold.

	Assessment statement	Obj	Teacher's notes
A.2.8	Outline what steps should be taken to prevent and to subsequently treat heat-related disorders.	2	
A.2.9	Describe how an athlete should acclimatize to heat stress.	2	Performing training sessions in similar environmental conditions (heat and humidity) for 5 to 10 days results in almost total heat acclimatization. Initially, the intensity of training should be reduced to avoid heat-related problems in these conditions. National representative teams/sportspeople choosing to acclimatize to the conditions of a host country during a major international sporting competition could be considered. **Aim 8:** The cost associated with the acclimatization of athletes using environmental chambers and/or expensive overseas training facilities (science and technology drives demand) could be explored. This also raises an ethical implication that poorer nations are unable to afford such support mechanisms and so their athletes are disadvantaged in comparison to athletes from wealthier nations.
A.2.10	Discuss the physiological and metabolic adaptations that occur with heat acclimatization.	3	Include increased plasma volume, increased sweat response and reduced rate of muscle glycogen utilization.
A.2.11	Outline the principal means by which the body maintains core temperature in cold environments.	2	Consider shivering, non-shivering thermogenesis and peripheral vasoconstriction.
A.2.12	Explain why the body surface area to body mass ratio is important for heat preservation.	3	For example, tall, heavy individuals have a small body surface area to body mass ratio, which makes them less susceptible to hypothermia. Small children tend to have a large body surface area to body mass ratio compared to adults. This makes it more difficult for them to maintain normal body temperature in the cold.
A.2.13	Outline the importance of wind chill in relation to body heat loss.	2	A chill factor created by the increase in the rate of heat loss via convection and conduction caused by wind.

	Assessment statement	Obj	Teacher's notes
A.2.14	Explain why swimming in cold water represents a particular challenge to the body's ability to thermoregulate.	3	Consider the thermal conductivity of water and air. During cold-water immersion, humans generally lose body heat and become hypothermic at a rate proportional to the thermal gradient and the duration of exposure. During swimming, the effect of cold water on body heat loss is increased because of greater convective heat loss. However, at high swimming speeds, the metabolic rate of the swimmer may compensate for the increased heat loss.
A.2.15	Discuss the physiological responses to exercise in the cold.	3	Limit this to muscle function and metabolic responses.
A.2.16	Describe the health risks of exercising in the cold, including cold water.	2	Limit to frostbite and hypothermia.
A.2.17	Discuss the precautions that should be taken when exercising in the cold.	3	The principal barrier is clothing, the amount of insulation offered by which is measured in a unit called a clo (1 clo = 0.155 m^2 K W^{-1}). Consider the insulating effect of clothing. Consideration of exercising in water is not required.

A.3 Non-nutritional ergogenic aids

4 hours

Aim 8: There are clear ethical issues in the use of performance-enhancing drugs.

	Assessment statement	Obj	Teacher's notes
A.3.1	Define the term *ergogenic aid*.	1	An ergogenic aid is any substance or phenomenon that improves an athlete's performance.
A.3.2	Describe, with reference to an appropriate example, the placebo effect.	2	
A.3.3	List five classes of non-nutritional ergogenic aids that are currently banned by the International Olympic Committee (IOC) and the World Anti-Doping Agency (WADA).	1	Specific names of banned substances need not be given. Limit to: • anabolic steroids • hormones and related substances • diuretics and masking agents • beta blockers • stimulants.

	Assessment statement	Obj	Teacher's notes
A.3.4	Discuss why pharmacological substances appear on the list of banned substances.	3	The discussion should focus on the moral obligation of athletes to compete fairly and on the safety issue around the use of these substances.
A.3.5	Discuss the proposed and actual benefits that some athletes would hope to gain by using anabolic steroids, erythropoietin (EPO), beta blockers, caffeine and diuretics.	3	The combined effects of taking two or more of the substances need not be considered. **TOK:** Decisions about what constitutes an acceptable level of risk could be discussed, together with differences between different groups and their views—scientists, sportsmen, doctors and spectators.
A.3.6	Outline the possible harmful effects of long-term use of anabolic steroids, EPO, beta blockers, caffeine and diuretics.	2	**Aim 8:** Our understanding of the effects, both ergogenic and harmful, of many banned substances (for example, anabolic steroids) has been hindered by the ethical concerns/problems about studying these agents in otherwise healthy individuals in randomized controlled trials.

A.4 Recovery from sports and exercise (HL only)

5 hours

	Assessment statement	Obj	Teacher's notes
A.4.1	Define *active recovery*.	1	Low-intensity exercise to promote recovery either immediately after, or in the days following, an intense training session or competition.
A.4.2	Outline the reasons for active recovery immediately after a training session or competition.	2	Consider: • raised circulation rate • enhanced blood lactate removal • accelerated raising of blood pH. **Link to topic 9:** Fatigue
A.4.3	Describe the indicators of recovery.	2	Include: • physiological indicators (for example, reduced blood lactate concentration) • symptomatic indicators (for example, reduced muscle soreness) • psychological indicators (for example, improved preparedness for the next session/ competition).
A.4.4	Outline the importance of planned recovery between workout sessions as part of a training programme.	2	Consider the fitness–fatigue model of training.

	Assessment statement	Obj	Teacher's notes
A.4.5	Outline the use of compression garments for sports recovery.	2	Compression garments (CGs) provide a means of applying mechanical pressure at the body surface, thereby compressing and supporting underlying tissue. They are relatively low cost, easy to use and are non-invasive. Although widely used across many different sports, evidence of any enhancement of recovery is inconclusive. **TOK:** The effectiveness of recovery interventions is difficult to quantify and these techniques are seen by some as pseudoscience. How can we know the difference between science and pseudoscience?
A.4.6	Define *cryotherapy*.	1	Body cooling for therapeutic purposes.
A.4.7	Describe cryotherapy procedures used for recovery in sports.	2	Consider: • whole body cooling (WBC) • cold water immersion (CWI) • contrast water therapy (CWT) • ice packs. **Int:** Hot and cold treatments have been used for therapeutic purposes in various cultures across the world for centuries.
A.4.8	Discuss the use of different types of cryotherapy for elite and recreational athletes.	3	Consider: • analgesic and anti-inflammatory effects for soft tissue • perception of enhanced recovery rates and improved performance • risks associated with exposure to prolonged or extreme cold • costs of the different therapies. There is pressure to maximize sporting performance, meaning that athletes often experiment with extreme interventions even if their safety and efficacy has not been established. **TOK:** Current recommendations for cryotherapy use are largely based on anecdotal rather than scientific research. What are the ethical considerations in allowing the use of these techniques?

A.5 Training and performance at altitude (HL only)

5 hours

	Assessment statement	Obj	Teacher's notes
A.5.1	State the height ranges for different categories of altitude.	1	• Near sea level: 0–500 m • Low altitude: 500–2,000 m • Moderate altitude: 2,000–3,000 m • High altitude: 3,000–5,500 m • Extreme altitude: above 5,500 m
A.5.2	Define *hypoxia*.	1	This is the condition in which the oxygen supply to cells is insufficient.
A.5.3	Outline the physiological effects of altitude.	2	Decreased air density and so decreased oxygen partial pressure cause hypoxia, resulting in: • respiratory responses (such as hyperventilation) • cardiovascular responses (such as elevated submaximal heart rate) • metabolic responses (for example. production of energy and lactic acid via glycolysis may be limited).
A.5.4	Outline the effects of altitude on fluid balance.	2	Ambient air at elevated altitude is cool but humidity is low, enhancing fluid loss and leading to dehydration. Fluid loss is exacerbated as a result of physical activity at altitude. Altitude-induced diuresis (increased urine production) also occurs.
A.5.5	Outline altitude training.	2	This is training for endurance athletes at altitudes above 2,000 m for several weeks or months in order to gain a competitive advantage in low-altitude competitions. Training at moderate or high altitude, where the oxygen partial pressure is low, can trigger the release of the hormone erythropoietin (EPO), which stimulates increased red blood cell production.

	Assessment statement	Obj	Teacher's notes
A.5.6	Evaluate the impact of altitude training for individual athletes and team sports players.	3	Consider the following. • Different approaches, for example: – live high, train high (LHTH) – live high, train low (LHTL) – live low, train high (LLTH). • Individual altitude training programmes—not all athletes benefit to the same degree from altitude training strategies. (Some athletes are non-responders to altitude.) Performance in different sports can be affected to a different extent by altitude training.
A.5.7	Evaluate the impact of altitude on sports performance.	3	Performance in different sports (for example, endurance events such as cross-country skiing compared to high-velocity events such as cycling) may be enhanced or impaired by the following effects. • Lower air density means drag is lower at high altitude. • Lower partial pressure of oxygen (pO_2) causes reduced maximum aerobic capacity. • Projectile motion (for example, ball sports, throwing, shooting and ski jumping) is also altered by reduced air density. **TOK:** High-altitude training camps are routinely used by endurance athletes. How do we decide if a training method is ethically justified?
A.5.8	Explain the adaptations resulting from altitude hypoxia.	3	Consider: • blood adaptations (for example, increased number of red blood cells) • muscle adaptations (for example, reduced lean body mass and increased capillary density in the muscles) • cardiorespiratory adaptations (for example, increase in pulmonary ventilation both at rest and during exercise).

	Assessment statement	Obj	Teacher's notes
A.5.9	Distinguish between the symptoms of *acute mountain sickness* (AMS), *high-altitude pulmonary edema* (HAPE) and *high-altitude cerebral edema* (HACE).	2	AMS—dizziness, headache, nausea or vomiting, shortness of breath, elevated heart rate. HAPE—accumulation of fluid in the lungs results in shortness of breath, elevated heart rate as well as coughing, wheezing while breathing and a bluish appearance to the skin. HACE—accumulation of fluid in the brain results in confusion, fever, photophobia, severe headaches, cessation of physical activities and eventually loss of consciousness.
A.5.10	Describe how to prevent high-altitude illness for athletes.	2	• Screen for pre-existing medical conditions. • Promote hydration. • Ascend gradually. • Introduce participation in exercise gradually. • Use medication to prevent AMS, for example, acetazolamide (a respiratory stimulant).

Option B: Psychology of sports (15 hours SL, 25 hours HL)

B.1 Individual differences

5 hours

	Assessment statement	Obj	Teacher's notes
B.1.1	Define the term *personality*.	1	There are many definitions of personality; for the purpose of this course the following definition will be used. "Those relatively stable and enduring aspects of individuals which distinguish them from other people, making them unique but at the same time permit a comparison between individuals" (Gross 1992). **TOK:** There is significant disagreement in personality research regarding issues of validity, reliability and sophistication of theoretical models.
B.1.2	Discuss social learning theory and personality.	3	Limit to Bandura's (1977) social learning theory.
B.1.3	Discuss the interactionist approach to personality.	3	
B.1.4	Outline issues associated with the measurement of personality.	2	Limit to: • data collection (interviews, questionnaires, observing behaviour) • validity and reliability issues • ethical issues: confidentiality, use of results, predicting performance. **TOK:** Issues relating to measurement.
B.1.5	Evaluate the issues in personality research and sports performance.	3	Consider: • athletes versus non-athletes • personality and sports type • predicting performance. Refer to the positions adopted by the skeptical and credulous groups of psychologists.

B.2 Motivation

3 hours

	Assessment statement	Obj	Teacher's notes
B.2.1	Define the term *motivation*.	1	Motivation is "the internal mechanisms and external stimuli which arouse and direct our behaviour" (Sage 1974).
B.2.2	Outline the types of motivation.	2	Limit to intrinsic and extrinsic motivation theory.
B.2.3	Discuss the issues associated with the use of intrinsic and extrinsic motivators in sports and exercise.	3	Limit to how extrinsic rewards influence intrinsic motivation. Extrinsic rewards seen as controlling of behaviour. Extrinsic rewards providing information about their level of performance. Extrinsic rewards will enhance intrinsic motivation when the reward provides positive information with regard to the performer's level of competence.
B.2.4	Describe Atkinson's model of achievement motivation.	2	
B.2.5	Outline goal orientation theory.	2	Limit to: • reasons for participation (achievement goals) • differing meanings that success or failure has for the performer (task versus outcome orientation).
B.2.6	Describe attribution theory and its application to sports and exercise.	2	Limit to Weiner's classification for causal attributions. • Locus of stability • Locus of causality • Locus of control • Self-serving bias • Learned helplessness

B.3 Mental preparation for sports

4 hours

	Assessment statement	Obj	Teacher's notes
B.3.1	Define the term *arousal*.	1	
B.3.2	Describe the theoretical approaches to arousal.	2	Limit to: • drive reduction theory • inverted-U hypothesis • catastrophe theory.
B.3.3	Draw and label a graphical representation of the arousal–performance relationship.	1	Refer to the theories of arousal in B.3.2.
B.3.4	Discuss the emotions that may influence an athlete's performance or experience in a physical activity.	3	Participation in sports and exercise influences a range of participant emotions such as depression, anxiety and pleasure. Limit to a discussion of the emotions that may be prevalent in physical activity. This may include: • positive emotions such as excitement, relief, pride • negative emotions such as anger, guilt, shame, anxiety, boredom • specific emotions that have a discrete effect on performance (for example, a negative mood is more likely to prime us to remember negative memories of past failures, and thus reduce our feelings of confidence to perform; similarly, a positive mood is more likely to prime us to remember positive previous outcomes, and increase our confidence to perform).
B.3.5	Define the term *anxiety*.	1	
B.3.6	Distinguish between *cognitive* and *somatic anxiety*.	2	
B.3.7	Distinguish between *trait* and *state anxiety*.	2	
B.3.8	Evaluate how anxiety is measured.	3	Limit to: • trait anxiety: Sport Competition Anxiety Test (SCAT) • state anxiety: Competitive State Anxiety Inventory-2 (CSAI-2R). **TOK:** Issues relating to measurement.

	Assessment statement	Obj	Teacher's notes
B.3.9	Describe the stress process in sports.	2	Defined as a substantial imbalance between the demand (physical and/or psychological) and response capability, under conditions where failure to meet that demand has important consequences. Include: • causes of stress (environmental demand) • stress response (person's reactions) • stress experience (psychological interpretation) • actual behaviour (outcome).

B.4 Psychological skills training

3 hours

The competitive process is complex and multifaceted. A performer is affected by a range of factors (personality, motivation, arousal, emotional effect). One aim of a sports psychologist is to manipulate these factors to enhance optimal performance. This section examines several fundamental interventions and evaluates their benefits and limitations.

	Assessment statement	Obj	Teacher's notes
B.4.1	Discuss psychological skills training (PST).	3	Refers to the systematic and consistent practice of mental or psychological skills. Include the following issues. PST: • is not just for elite athletes • is not just for problem athletes • does not provide quick-fix solutions. Consider the three phases of a PST programme: • education • acquisition • practice.
B.4.2	Outline goal setting.	2	Include: • associated with enhancing self-confidence and motivation • SMARTER (specific, measurable, achievable, realistic, time, evaluate, review) goals • types of goals (outcome, performance, process).

	Assessment statement	Obj	Teacher's notes
B.4.3	Evaluate mental imagery.	3	Associated with concentration enhancement, self-confidence, skill acquisition, emotional control, practice strategy and coping with pain and injury. Include: • external and internal imagery • protocol for imagery interventions.
B.4.4	Outline relaxation techniques.	2	Associated with arousal regulation, reducing somatic and cognitive anxiety. Include: • progressive muscular relaxation (PMR) • breathing techniques • biofeedback.
B.4.5	Outline self-talk techniques.	2	Associated with concentration, attention, cognitive regulation and motivation enhancement. Include: • positive and negative self-talk • thought stopping.

B.5 Talent identification and development (HL only)

5 hours

	Assessment statement	Obj	Teacher's notes
B.5.1	Outline the term talent.	2	Talent is a multidimensional concept identified by characteristics that are only partially genetically determined. It involves psychological as well as physiological, motor, sociological and environmental factors.
B.5.2	Distinguish between *talent identification* (TI) and *multidimensional talent identification and development* (TID) processes.	2	(Traditional) Talent identification (TI) processes include: • subjective assessments • objective testing that may be physiological (such as aerobic capacity, anaerobic power, speed and strength), anthropometric (such as height, weight, body composition) and performance-based (such as skill and agility).

	Assessment statement	Obj	Teacher's notes
			Multidimensional talent identification and development (TID) recognizes that talent also evolves as a result of an athlete actively interacting with the environment and having the resilience to cope with the challenges and setbacks they encounter. The evolution of talent can be facilitated through the application of **psychological** behaviours that include: • mental imagery • realistic goal setting • effective evaluation of performance/self-evaluation • self-reinforcement • training to a high intensity (outside comfort zone) • handling failure • performance arousal and control. Multidimensional TID incorporates the following. • Monitoring an individual's progress and behaviour during a development programme **over time**. The ability to adapt is a key feature of true elite athletes and is unlikely to be identified by snapshot observations. • Balancing weaknesses in one area and strengths in other areas (for example, height and speed as well as dedication and commitment when faced with adversity in basketball). • Providing athletes with opportunities to develop **psychological behaviours** along with **sport-specific skills** over long periods of time that facilitate progress from one stage of development to another. (See the stages of development in B.5.3 below.) **Aim 8:** Discuss how the effect of maturation makes prediction of adult performance from adolescent data difficult. **TOK:** There is a significant disagreement in TID research owing to the complexity of talent: many key performance determinants in sports are not fixed and are not easily measurable. How can we decide which ways of knowing are most reliable when seeking to answer questions?

	Assessment statement	Obj	Teacher's notes
B.5.3	Explain the evolution of talent for athlete development.	3	Bloom (1985) and Cote (1999) suggest that the **four stages of development** that an elite performer is likely to progress through are as follows. 1. Initiation stage 2. Development stage 3. Mastery stage 4. Maintenance (perfection) stage Different psychological behaviours (such as coach- or parent-led versus self-determined motivation) and sports participation goals (such as enjoyment, skill development or performance mastery) will vary according to the athlete's stage. The existence of stages suggests that as athletes encounter **opportunities** (such as the opportunity to train with a specialist coach, increase in hours of deliberate practice), **obstacles** (such as an injury) and **progressions** (such as transition to the next stage of development), many aspects of their performance may become unstable. The developing athlete uses psychological behaviours to cope with these unstable periods. These behaviours are key to continued development of the individual and consistent production of world-class performances by elite athletes.
B.5.4	Outline talent transfer for elite athletes changing to a second sport.	2	Talent transfer is a reduction or cessation of participation in one sport in order to pursue another sport that involves similar skills or physiological requirements. • It may be prompted by injury, a plateau in performance, loss of motivation or retirement. • It may be initiated by the athlete or co-ordinated by a sporting organization. • It commonly prolongs an athlete's sporting career and can lead to greater success than that in the first sport. Progress through the stages of development in the new sport is usually rapid because the athlete: • has the capacity to use psychological behaviours to respond to challenges • can exploit existing physiological traits and motor skills • has improved motivation. Examples include changes from sprinting or cycling to winter sports such as skeleton luge or bobsleigh, and changes from gymnastics to diving or pole vaulting.

B.6 Self-determination theory and self-regulated learning (HL only)

5 hours

	Assessment statement	Obj	Teacher's notes
B.6.1	Describe self-determination theory (SDT).	2	Self-determination theory (SDT) describes how the level and the amount of energy that athletes devote to learning activities is a dynamic continuum characterized by a balance between: • autonomy—making one's own decisions about what we do and being in control of ourselves and our behaviours (for example, training because you want to, not because someone says you should) • competence—feeling able to accomplish a task (for example, completing a cross-country run without having to stop for a rest) • relatedness—the feeling of a shared experience with others, of belonging to and being accepted by a group (for example, being part of a basketball team).
B.6.2	Describe self-regulated learning (SRL).	2	Self-regulated learning (SRL) refers to the processes that assist learners in managing their own thoughts, behaviours and emotions in order to control their own learning experiences. SRL encourages athletes to become more independent in their learning and so enhances learning outcomes. Athletes exert this control by planning and regulating their own actions towards their learning goals. There are four interdependent cyclical phases (Pintrich 2000) through which an athlete manages their progression. 1. Forethought phase (goal-setting and planning) 2. Monitoring phase (tracking progress and awareness of current performance in relation to goals) 3. Control phase (adapting learning strategies to better complete the task) 4. Reflection phase (evaluating performance with respect to goals and the effectiveness of the chosen strategy) Self-reflections influence athletes' future planning/goals, prompting the cycle to begin again.

	Assessment statement	Obj	Teacher's notes
B.6.3	Discuss the relationship between self-regulated learning and motivation in sports.	3	Motivation is a critical factor in the self-regulated learning framework. Forethought (planning) phase • Athletes who do not see value in tasks are less likely to spend much time setting goals and planning strategies. • Higher self-efficacy beliefs increase the use of self-regulation strategies. Monitoring phase • Intrinsic motivation affects level of effort in completing tasks and use of self-regulation strategies. Reflection phase • An athlete's causal attributions (factors athletes attribute to their success or failure) affect whether or not they choose to engage in an activity and utilize self-regulation strategies for similar future activities. Athletes who are motivated to learn are more likely to invest the time and energy needed to learn and apply SRL skills. Similarly, athletes who are able to successfully employ self-regulation strategies often become more motivated to complete learning tasks.

Option C: Physical activity and health (15 hours SL, 25 hours HL)

C.1 Hypokinetic disease

1.5 hours

	Assessment statement	Obj	Teacher's notes
C.1.1	Distinguish between the terms *habitual physical activity*, *exercise*, *sports* and *physical fitness*.	2	
C.1.2	Define the term *hypokinetic disease*.	1	Hypokinetic disease is a disease associated with physical inactivity.
C.1.3	Outline the following hypokinetic diseases: coronary heart disease, stroke, hypertension, obesity, type 2 diabetes and osteoporosis.	2	
C.1.4	Discuss how studies of different populations provide evidence of the link between physical activity and hypokinetic disease.	3	**Int:** Consider how various populations have changed their lifestyles from one of high physical activity (traditional, agricultural-based living) to one of low physical activity ("westernized" living).
C.1.5	Discuss the relationship between major societal changes and hypokinetic disease.	3	Examples of changes include the proliferation of the motor vehicle, changes in employment and working patterns, and changes in diet such as the rise of fast food.

C.2 Cardiovascular disease

3 hours

	Assessment statement	Obj	Teacher's notes
C.2.1	Outline the coronary circulation.	2	Left and right coronary arteries, circumflex artery and left anterior descending artery should be identified.
C.2.2	Outline what is meant by the term *atherosclerosis*.	2	A detailed explanation of the processes leading to atherosclerosis is not required. The general idea that an artery becomes damaged and blocked with cholesterol and other material (the formation of atherosclerotic plaque) is sufficient.

	Assessment statement	Obj	Teacher's notes
C.2.3	List the major risk factors for cardiovascular disease.	1	Limit to: • cigarette smoking • high blood pressure (hypertension) • high cholesterol and LDL-cholesterol • low HDL-cholesterol • diabetes • obesity • physical inactivity • age • gender • ethnicity • family history.
C.2.4	Explain the concept of risk factors in cardiovascular disease.	3	Consider the individual and accumulative effects (that is, the effects of having one risk factor versus a cluster) of the major risk factors for cardiovascular disease. **TOK:** The distinction between correlation and cause could be made here, and the need for carefully controlled experiments to test whether a correlation is the result of a causal link. An interesting discussion is whether physical inactivity is causal or correlative. **Aim 8:** An interesting topic for consideration is the validity of animal experimentation as a part of the process of uncovering the causes of disease in humans and in the development of new pharmacological treatments. **Int:** This is clearly a good opportunity to consider differences in cardiovascular disease risk in different populations. There are many examples where different ethnic groups appear to vary in their susceptibility to cardiovascular disease and this could be considered from the perspective of genes (nature) versus lifestyle (nurture). **Aim 7:** Use of sophisticated imaging techniques and technologies could be mentioned here. For example, use of magnetic resonance imaging (MRI) and gamma cameras for capturing information about the extent and anatomical positioning of atherosclerotic plaque.

	Assessment statement	Obj	Teacher's notes
C.2.5	Discuss how a lifestyle of physical inactivity increases the risk of cardiovascular disease.	3	Discussion of the physiological mechanisms is not required (for example, why inactivity "causes" high blood pressure). Emphasis should be on the concept that people who are physically inactive are more likely to have risk factors for cardiovascular disease. High blood pressure, obesity, type 2 diabetes and low HDL-cholesterol should be considered.

C.3 Physical activity and obesity

2 hours

	Assessment statement	Obj	Teacher's notes
C.3.1	Describe how *obesity* is determined.	2	Obesity is, by definition, an excess of body fat but, in reality, obesity is determined using indirect measurements of body fat, for example, body mass index (BMI) and waist girth. The description should be restricted to these two techniques. The BMI values that define normal weight, overweight and obesity are widely accepted. Waist girth values that define abdominal obesity are gender- and ethnicity- specific and reflect different levels of disease risk in obesity. **Int:** BMI is the most widely used method of measuring obesity, yet its limitations as a measure of "fatness" are well known. The World Health Organization (WHO) cut-off points for underweight, overweight, obesity and fat distribution may need revision because the relationship between body mass index and body composition, and between indices of fat distribution and the actual amount of visceral fat, differ across ethnic groups. **Aim 8:** Obesity, particularly childhood obesity, is associated with social stigmatization and bullying. This raises an ethical issue around the routine, large-scale screening for obesity. **Aim 7/Aim 8:** Sophisticated imaging techniques such as computed tomography (CT), MRI and dual energy X-ray (DXA) provide state-of-the-art methods for measuring body fat. However, they are costly, not widely available and, in the case of CT and DXA, expose the individual to radiation.

	Assessment statement	Obj	Teacher's notes
C.3.2	Outline the major health consequences of obesity.	2	Limit to: • cardiovascular disease and hypertension • type 2 diabetes • osteoarthritis • respiratory problems • some cancers such as bowel cancer. Consideration of the effects of age, gender and ethnicity is not required.
C.3.3	Discuss the concept of energy balance.	3	Energy balance is affected mainly by food intake, resting metabolic rate and physical activity. Consider the effects of positive and negative energy balance on body weight and composition.
C.3.4	Outline how chemical signals arising from the gut and from the adipose tissue affect appetite regulation.	2	Only a simple account is expected. Hormones are produced by the stomach and small intestine after eating, and by adipose tissue (leptin). These pass to an appetite control centre in the brain that regulates feelings of hunger and satiety. **TOK:** Leptin was first discovered in mice and led to the expectation that obesity could be "cured". Later discoveries in humans have shown that this initial expectation was misplaced. This is a good example of how scientific discoveries can sometimes be taken out of context by the media and lead to false hope by individuals affected by certain conditions.

C.4 Physical activity and type 2 diabetes

2 hours

	Assessment statement	Obj	Teacher's notes
C.4.1	Compare type 1 and type 2 diabetes.	3	Type 1 diabetes is an autoimmune disorder resulting in the destruction of the insulin-producing cells of the pancreas. It usually manifests in young people. Type 2 diabetes is a disease of insulin resistance, particularly in skeletal muscle, and is highly related to obesity and older age. Past terms for these disorders include insulin-dependent and non-insulin-dependent diabetes (IDDM and NIDDM); these terms are no longer used. Consider also the way in which diabetes is treated: type 1 with insulin; type 2 with diet and exercise, oral medication and/or insulin. Other less common forms of diabetes do not need to be discussed. Cross-reference topic 3.2.4.

	Assessment statement	Obj	Teacher's notes
C.4.2	Discuss the major risk factors for type 2 diabetes.	3	Limit to: • obesity • physical inactivity • a diet high in saturated fat • and family history. **TOK:** The nature of risk factors and the difficulties of making decisions about the relative influence of nature and nurture could be discussed. **Int:** There are clear differences in susceptibility to type 2 diabetes, with some populations having higher rates of incidence. For example, the experience of the Pima Indians is well-documented. This could lead to a wider consideration of the diversity in human societies combined with the need for parity of esteem. **Aim 8:** Ethical and economic decisions as to who should be treated, that is, the blood glucose level at which diabetes is diagnosed, could be considered.
C.4.3	Outline the health risks of diabetes.	2	Limit to: • blindness • kidney disease • nerve damage • cardiovascular disease.

C.5 Physical activity and bone health

2.5 hours

	Assessment statement	Obj	Teacher's notes
C.5.1	Outline how bone density changes from birth to old age.	2	Bone density increases from birth to around 35–45 years of age. Typically, females achieve a lower peak bone density than males. From this age onwards bone density decreases.
C.5.2	Describe the risk of osteoporosis in males and females.	2	
C.5.3	Outline the longer-term consequences of osteoporotic fractures.	2	Limit to: • loss of independence • development of secondary complications as a result of long-term hospitalization and pneumonia.

	Assessment statement	Obj	Teacher's notes
C.5.4	Discuss the major risk factors for osteoporosis.	3	Limit to: • lack of dietary calcium • cigarette smoking • slim build (ectomorphy) • lack of estrogen associated with early menopause and female triad (athletic amenorrhea) • physical inactivity.
C.5.5	Discuss the relationship between physical activity and bone health.	3	Weight-bearing physical activity is essential for bone health but, in some cases, intense training in weight-conscious athletes gives rise to low body weight/body fat and eating disorders, leading to menstrual dysfunction and bone demineralization (osteoporosis). Changes in bone density are site-specific and resistance training results in greater changes than endurance training. Consideration of the importance of weight-bearing exercise in children should be given.

C.6 Prescription of exercise for health

1.5 hours

	Assessment statement	Obj	Teacher's notes
C.6.1	Outline physical activity guidelines for the promotion of good health.	2	**Int:** Consider current World Health Organization (WHO) recommendations for minimal levels of physical activity in the promotion of good health.
C.6.2	Describe the aims of exercise in individuals with a hypokinetic disease.	2	Limit to: • to make the most of limited functional capacities • to alleviate or provide relief from symptoms • to reduce the need for medication • to reduce the risk of disease reoccurrence (secondary prevention) • to help overcome social problems and psychological distress.
C.6.3	Discuss the potential barriers to physical activity.	3	Limit to: • uncontrolled disease state (unstable angina, poorly controlled diabetes, uncontrolled hypertension) • hazards of exercise (for example, cycle and swimming accidents) • musculoskeletal injuries • triggering of other health issues (for example, heart attack, respiratory tract infections).

C.7 Exercise and psychological well-being

2.5 hours

	Assessment statement	Obj	Teacher's notes
C.7.1	Define the term *mood*.	1	A state of emotional or affective arousal of varying, and not permanent, duration. Feelings of elation or happiness lasting several hours or even a few days are examples of mood.
C.7.2	Outline the effects of exercise on changing mood states.	2	**Aim 8:** Limit to: • research suggests exercise is one of the most effective methods of alleviating a bad mood • research supports the use of exercise in modifying fatigue, anger, anxiety, depression, and enhancing the positive moods of vigour, clear thinking, energy, alertness, increased sense of well-being.
C.7.3	Outline how exercise enhances psychological well-being.	2	No single theory explains the process fully. It is likely that an interaction between both physiological and psychological factors underpin the process. Limit to: • physiological—increases in cerebral blood flow, changes in brain neurotransmitters (norepinephrine, endorphins, serotonin), increase in maximal oxygen consumption and delivery of oxygen to cerebral tissues, reductions in muscular tension, structural changes in the brain • psychological—distraction from daily hassles and routine, enhanced feeling of control, feeling of competency, positive social interactions, improved self-concept and self-esteem.

	Assessment statement	Obj	Teacher's notes
C.7.4	Explain the role of exercise in reducing the effects of anxiety and depression.	3	Limit to: • anxiety reduction—acute effects of exercise on state anxiety, compounding effect of intensity and duration of exercise, chronic effects of exercise on trait anxiety • depression reduction—note this is a clinical condition treated by medication. Exercise has been seen to play a significant role in alleviating depression although it is a correlational relationship; no causal link has been established. Include the nature of the exercise programme (enjoyable, aerobic or rhythmic, absence of interpersonal competition, closed and predictable environment, moderate intensity, 20–30 minutes several times a week).
C.7.5	Discuss potential personal and environmental barriers to physical activity.	3	Discussion should be based on exercise adherence, limited to: • personal factors – demographic variables – cognitive variables – past behaviours • environmental factors – social environment – physical environment – time – characteristics of physical activity offered – leader qualities – social and cultural norms within various ethnic groups.
C.7.6	Describe strategies for enhancing adherence to exercise.	2	**Aim 8:** Limit to: • environmental approaches—prompts, contracting, perceived choice • reinforcement approaches—rewards for attendance and participation, external feedback, self-monitoring • goal-setting and cognitive approaches—associative versus dissociative focus during exercise • social support approaches—role of significant others (spouse, family members, friends), including joining in, adjusting routines, transportation, providing equipment.

	Assessment statement	Obj	Teacher's notes
C.7.7	Outline the possible negative aspects of exercise adherence.	2	**Aim 8:** Limit to: • negative addiction to exercise—life choices and relationship issues • symptoms of negative exercise—stereotyped pattern with a regular schedule of once or more daily, increased priority of exercise, negative mood affect with withdrawal, increased tolerance to exercise, subjective awareness of compulsion to exercise.

C.8 Public health (HL only)

4 hours

	Assessment statement	Obj	Teacher's notes
C.8.1	Distinguish between *non-communicable* and *communicable diseases*.	2	Non-communicable diseases are not passed from person to person. They are usually of long duration and slow progression. Examples include cardiovascular diseases, skin cancer, some chronic respiratory diseases and diabetes. Communicable diseases are caused by an infectious agent or its toxins, which pass by direct or indirect transmission from person to person or via an animal, vector or the inanimate environment. Examples include pneumonia, malaria and influenza. **Int:** The relative importance of communicable and non-communicable diseases varies in different parts of the world.
C.8.2	Outline population attributable risk (PAR).	2	Population attributable risk (PAR) is a calculation of the percentage or proportion of public health burden that is caused by a particular risk factor, for example, smoking or physical inactivity. PAR indicates the proportion of deaths or illnesses that would not occur if the risk factor was removed. For example, a PAR for lung cancer deaths associated with moderate smoking calculated as 52% means that 52% of lung cancer deaths would **not** occur if people in the population did not smoke. The usefulness of the calculation is based on the assumption of a causal link between the risk factor and health problems.

	Assessment statement	Obj	Teacher's notes
C.8.3	Outline the use of population attributable risk (PAR) for prioritizing public health initiatives.	1	Limit to coronary heart disease (CHD) and cancer, and their correlation with risk factors such as physical inactivity, smoking and obesity. **Int:** Consider different uses of PAR values in different parts of the world. **TOK:** How does public perception of health influence scientific progress and the implementation of public health policies?
C.8.4	Explain the relationship between moderate exercise and health.	3	Consider the following. • Walking is associated with lower risk of mortality, CHD/cardiovascular disease (CVD) and type 2 diabetes owing to: – improved metabolic rates and VO_2max – increased energy expenditure – improved plasma lipid profiles – decreased adiposity – decreased blood pressure – reduced risk of skeletal injuries. **Int:** Walking has been a feature of the lifestyle in many cultures for many years.
C.8.5	Outline the causes of sudden cardiac death (SCD) in athletes.	2	Sudden cardiac death (SCD) is related to: • underlying medical history (for example, genetic disorders such as hypertrophic cardiomyopathy (HCM)) • intensity of exercise • habitual weekly exercise. **TOK:** Electrocardiogram screening has been used to assess the risk of SCD, but there is no agreement on the effectiveness of this technique. How can we know if evidence is valid for use in making predictions?

C.9 Injury and hazards (HL only)

6 hours

	Assessment statement	Obj	Teacher's notes
C.9.1	Define *musculoskeletal injuries*.	1	Musculoskeletal injuries covers a range of disorders involving muscles, bones, tendons, blood vessels, nerves or related soft tissue including sprains, strains and inflammation.
C.9.2	Distinguish between *compression*, *tension* and *shearing* injuries.	2	Compression: Compact injury to a specific body part that causes bleeding, superficial or deep tissue bruising, broken bones or joint injuries (for example, colliding with another player or equipment). Tension: Injury that occurs when a tissue is stretched beyond its normal limits (for example, when landing from a jump). Shearing: Friction injury caused by two surfaces rubbing together (for example, contact between the skin and the ground), which can also affect other connective tissues, such as cartilage.
C.9.3	Distinguish between *acute* and *chronic* injuries.	2	Acute injuries: These occur suddenly as a result of a specific injury mechanism (for example, fractured wrist, anterior cruciate ligament tear, concussion). Chronic injuries: These develop over a period of several weeks and are often caused by repetitive activity (for example, tennis elbow, shin splints).
C.9.4	Outline the types of injuries common in different sports.	2	Consider the following. • Lower limb injuries represent the highest percentage of injuries to athletes in many sports, for example, football, running and skiing. • Types of lower limb injuries include meniscus tears, tendinosis, sport-induced osteoarthritis, muscle strains and ligament sprains. • Spinal injuries, including fractures, occur in sports such as diving, gymnastics and horse riding. • Head injuries such as concussion can occur in cycling and rugby.

	Assessment statement	Obj	Teacher's notes
C.9.5	Outline the common causes of running-related injuries.	2	Consider running in a variety of sporting contexts. Injuries can be caused by impact and repetition of the same movement (overuse injury) but other factors might include: • rapid increase in training distance or intensity • running surface • footwear • previous injuries • running experience • biomechanical imbalance • twists and turns.
C.9.6	Explain how risks and hazards of exercise can be reduced.	3	Risk and hazard prevention strategies are sports-specific and may differ according to the individual athlete. They include: • regular moderate exercise • protective equipment • regular health and wellness evaluations with a medical professional • injury prevention strategies (for example, correct warm-up and cool-down, and stretching routines) • injury prevention education for coaches, referees and athletes.
C.9.7	Evaluate the benefits and hazards of exercise with regard to health.	3	Consider the following. • The risk associated by strenuous exercise may be outweighed by the benefits of physical activity. • There is evidence that habitual, moderate to vigorous exercise protects against CHD. • Some forms of moderate exercise, such as jogging, walking and cycling, also pose a risk of injury through collisions with vehicles and falls. **Link to topic 13:** Exercise and immunity

Option D: Nutrition for sports, exercise and health (15/25 hours)

D.1 Digestion and absorption

3 hours

	Assessment statement	Obj	Teacher's notes
D.1.1	Outline the features of the principal components of the digestive system.	2	Limit to: • mouth—mechanical digestion and chemical digestion • esophagus—peristalsis action • stomach—rugae, lumen, mucous coating • small intestine—villi and microvilli increase area for absorption • large intestine—water balance, vitamin absorption • pancreas—production of enzymes • liver—production of bile • gall bladder—storage of bile.
D.1.2	State the typical pH values found throughout the digestive system.	1	Mouth: 5.5 to 7.5 Stomach: 1.0 to less than 4.0 Small intestine: 6.0 to 8.0
D.1.3	Describe the function of enzymes in the context of macronutrient digestion.	2	Limit to their role as a catalyst, that they are proteins themselves (thus activity is highest under optimum conditions of temperature and pH), and that each reaction requires a specific enzyme.
D.1.4	Explain the need for enzymes in digestion.	3	Refer to the need for increasing the rate of digestion at body temperature.
D.1.5	List the enzymes that are responsible for the digestion of carbohydrates, fats and proteins from the mouth to the small intestine.	1	Carbohydrates: salivary amylase, pancreatic amylase Fats: pancreatic lipase Bile is produced by the liver and is involved in the digestion of fats. Proteins: pepsin, trypsin

	Assessment statement	Obj	Teacher's notes
D.1.6	Describe the absorption of glucose, amino acids and fatty acids from the intestinal lumen to the capillary network.	2	Glucose, fatty acids and amino acids cross the brush-border membrane, pass through the cytosol of the absorptive cell and cross the basolateral membrane before entering the capillary network (glucose and amino acids) or the lymphatic system (fats). Consideration of more complex processes such as the re-esterification of fatty acids, and consideration of fatty acid binding proteins (apolipoproteins and chylomicrons) is not required. Consideration of specific amino acid transporters, glucose transporters and the sodium–glucose co-transporter are also not required at this level.

D.2 Water and electrolyte balance

4 hours

	Assessment statement	Obj	Teacher's notes
D.2.1	State the reasons why humans cannot live without water for a prolonged period of time.	1	Water: • is the basic substance for all metabolic processes in the body • regulates body temperature • enables transport of substances essential for growth • allows for the exchange of nutrients and metabolic end products.
D.2.2	State where extracellular fluid can be located throughout the body.	1	Extracellular fluid includes: • the blood plasma and lymph • saliva • fluid in the eyes • fluid secreted by glands and the digestive tract • fluid surrounding the nerves and spinal cord • fluid secreted from the skin and kidneys.
D.2.3	Compare water distribution in trained and untrained individuals.	3	
D.2.4	Explain that homeostasis involves monitoring levels of variables and correcting changes in levels by negative feedback mechanisms.	3	

	Assessment statement	Obj	Teacher's notes
D.2.5	Explain the roles of the loop of Henlé, medulla, collecting duct and ADH in maintaining the water balance of the blood.	3	When body fluid levels are low, receptors in the hypothalamus are stimulated. The hypothalamus stimulates the pituitary gland to release ADH. ADH acts on the kidneys, increasing water permeability of the renal tubules and collecting ducts, leading to increased re-absorption of water.
D.2.6	Describe how the hydration status of athletes can be monitored.	2	Consider how athletes monitor urine colour, urine osmolarity and variation in body mass loss.
D.2.7	Explain why endurance athletes require a greater water intake.	3	**Aim 8/TOK:** While increased water intake is a widely recognized and accepted method of minimizing dehydration during endurance events, recent reports in the literature of hyponatremia have alerted people to the harmful, life-threatening consequences of consuming too much low osmolality fluid. Some scientists have questioned the scientific process behind current recommendations for fluid replacement by suggesting that much of the research has been funded by the sports drink industry, which has a vested interest.
D.2.8	Discuss the regulation of electrolyte balance during acute and chronic exercise.	3	

D.3 Energy balance and body composition

2 hours

	Assessment statement	Obj	Teacher's notes
D.3.1	Define the term *basal metabolic rate* (BMR).	1	
D.3.2	State the components of daily energy expenditure.	1	Limit to: • basal metabolic rate (BMR) • thermic effect of physical activity • thermic effect of feeding.
D.3.3	Explain the relationship between energy expenditure and intake.	3	

	Assessment statement	Obj	Teacher's notes
D.3.4	Discuss the association between body composition and athletic performance.	3	Consider body composition from two components: fat and fat-free mass. A distinction between fat-free mass and lean body mass should be made. The discussion should include reference to typical levels of body fat and consider the accuracy of body fat measurements (see topic 6.1.7).
D.3.5	Discuss dietary practices employed by athletes to manipulate body composition.	3	**Aim 8:** Include dietary practices used to decrease body fat, for example, a recommended dietary approach and more controversial methods such as diet pills, fad diets and crash diets. Also include the significance of a high-protein diet for athletes aiming to increase muscle mass.

D.4 Nutritional strategies

6 hours

	Assessment statement	Obj	Teacher's notes
D.4.1	State the approximate glycogen content of specific skeletal muscle fibre types.	1	Limit fibre types to: • slow twitch (type I)—low-glycogen content • fast twitch (type IIa)—medium-glycogen content • fast twitch (type IIb)—high-glycogen content. Note: Type IIa and type IIb are high in glycogen content depending on training status.
D.4.2	Describe, with reference to exercise intensity, typical athletic activities requiring high rates of muscle glycogen utilization.	2	Cross-reference topic 3.3.11.
D.4.3	Discuss the pattern of muscle glycogen use in skeletal muscle fibre types during exercise of various intensities.	3	Cross-reference topic 4.1.4.
D.4.4	Define the term *glycemic index* (GI).	1	Glycemic index (GI) is the ranking system for carbohydrates based on the immediate effect of the food on blood glucose concentrations when compared with a reference food such as pure glucose.
D.4.5	List food with low and high glycemic indexes.	1	High (for example, glucose) =100 Medium (for example, brown rice) = 50 Low (for example, green vegetables) = less than 15

	Assessment statement	Obj	Teacher's notes
D.4.6	Explain the relevance of GI with regard to carbohydrate consumption by athletes pre- and post-competition.	3	The use of high GI foods post-exercise may assist the body in restoring its glycogen stores more rapidly, aiding refuelling prior to future training/ competition bouts. There is some evidence that lower GI foods may be beneficial prior to exercise and that our general diet, in terms of good health, should be based on carbohydrate foods with a low to medium GI.
D.4.7	Discuss the interaction of carbohydrate loading and training programme modification prior to competition.	3	Include nutritional strategies as well as training strategies, such as tapering prior to an event.
D.4.8	State the reasons for adding sodium and carbohydrate to water for the endurance athlete.	1	
D.4.9	Discuss the use of nutritional ergogenic aids in sports.	3	Limit to: • sports drinks, bars and gels • caffeine • creatine • bicarbonate. **Aim 8:** Include ethical, health and performance enhancement considerations.
D.4.10	State the daily recommended intake of protein for adult male and female non-athletes.	1	**Int:** The World Health Organization (WHO) recommends a minimum of 0.8 g kg^{-1} body weight.
D.4.11	List sources of protein for vegetarian and non-vegetarian athletes.	1	
D.4.12	Discuss the significance of strength and endurance training on the recommended protein intake for male and female athletes.	3	
D.4.13	Outline the possible harmful effects of excessive protein intake.	2	

D.5 Glucose uptake (HL only)

4 hours

	Assessment statement	Obj	Teacher's notes
D.5.1	State the normal levels of blood glucose at rest.	1	The human body normally keeps blood glucose level very stable (between 4.0 mmol/L–4.5 mmol/L). Consider: • pre- and post-exercise levels • pre- and post-ingestion levels.
D.5.2	Outline the causes of hypoglycemia and hyperglycemia.	2	Hypoglycemia • Insufficient food intake • Excessive exercise • High insulin levels among diabetics Hyperglycemia • Infections (such as a cold or flu) • Low insulin levels in diabetics Note: Hyperglycemia usually develops slowly, over several hours or days.
D.5.3	Explain the transportation of glucose across the cell membrane when at rest and during physical activity.	3	Include the following points. • Glucose uptake into a cell is facilitated by the glucose transport proteins GLUT4 and GLUT1. • Muscle fibres also contain glucose transport proteins GLUT1 and GLUT4. • During rest, most glucose enters cells via the GLUT1 transporters. • GLUT4 transporters are stored inside intracellular vesicles that are translocated to the cell membrane, when needed, to allow for greater glucose movement into the cell. • GLUT4 transporters can be stimulated during rest by raised levels of insulin after eating. • GLUT4 transporters can also be stimulated, without insulin, during physical exercise. This is the result of other stimuli such as calcium ions. • Glucose taken into the muscle cells is quickly converted to glucose-6-phosphate; this ensures that the concentration gradient for glucose movement is maintained.
D.5.4	Outline the effect of training on an athlete's ability to take in glucose at the cellular level.	2	Exercise increases the amount of GLUT4 transport protein in cells which, in turn, enables a higher rate of glucose uptake into the cell for use as a fuel.

D.6 The effects of alcohol on performance and health (HL only)

3 hours

Int: Many countries have guidelines or recommendations for the intake of alcohol in relation to health, but there is considerable variation from one country to another. There are also different cultural viewpoints on positive and negative impacts of alcohol consumption.

	Assessment statement	Obj	Teacher's notes
D.6.1	Describe the acute effects of excess alcohol on the body.	2	Limit to: • hydration and kidney function • cardiovascular system • thermoregulation • neurologic systems.
D.6.2	Outline the possible effects of excessive chronic alcohol intake on body systems.	2	Limit to liver, kidney, heart and brain.
D.6.3	Discuss the effects of alcohol on athletic performance.	3	Consider ergogenic and ergolytic effects from alcohol, for example: • anti-tremor • balance • power and strength • endurance • speed • coordination • reaction time (RT) and cognitive processing • cardiac function • inhibition of gluconeogenesis. Low amounts of alcohol (0.02–0.05 g/dL) might assist in sports such as shooting and archery by reducing hand tremors, but levels above this will have a negative impact. Any amount of alcohol is likely to impair performance in activities such as running and power sports.

D.7 Antioxidants (HL only)

3 hours

	Assessment statement	Obj	Teacher's notes
D.7.1	Outline the role of antioxidants in the body.	2	Antioxidants are molecules that can prevent or limit the damaging effects of free radicals by turning them into substances that are far less reactive. Free radicals are produced in the body as a by-product of normal cellular function. Nutrients such as vitamins A, C, and E are antioxidants. Several minerals such as selenium, copper and manganese are components of enzymes also involved in defence against free radicals. Berries, red grapes, kale, broccoli and tea are examples of foods that contain antioxidants.
D.7.2	Explain the harmful effects of free radicals at the cellular level.	3	A free radical (or a reactive oxygen species (ROS)) is a particle that possesses at least one unpaired electron. Free radicals in the body include: • superoxide • hydroxyl • nitric oxide. These cause damage by removing electrons from parts of the cell in order to create paired electrons in their own structures. Free radicals can: • remove electrons from cell and mitochondrial membranes, thereby affecting their permeability • remove electrons from molecules such as enzymes and DNA, thereby impairing their function.
D.7.3	Describe free radical production during exercise.	2	Free radicals are produced as a by-product of normal cell function, and cells produce natural antioxidants to counteract them. Exhaustive exercise generates high levels of free radicals that cannot be controlled by natural antioxidants so that damage to cells may occur. This is known as oxidative stress. Training partially reduces the build-up of free radicals as a result of exhaustive exercise.

	Assessment statement	Obj	Teacher's notes
D.7.4	Evaluate the role of antioxidants for combating the effects of free radicals.	3	Antioxidants are found in many foods, especially fruits and vegetables, and so are consumed as part of a healthy, well-balanced diet. Many athletes consume antioxidants in dietary supplements as an extra defence against free radical damage. There is no consistent evidence that these supplements reduce oxidative stress or have a positive impact on training or performance unless a pre-existing dietary deficiency exists. Excess intake (above the recommended daily allowance (RDA)) may have detrimental effects on the body. A lack of adequate regulation of the supplement industry means that some products are poorly formulated and may even contain banned substances. **TOK:** Consuming supplements of vitamins C or E is widely believed to protect from damage by free radicals in sports, even though there is no consistent evidence that this is true. Under what circumstances do we allow our beliefs to dictate our behaviour?

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 are that it should support curricular goals and encourage appropriate student learning. Both external and internal assessments are used in the Diploma Programme. 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.

The Diploma Programme primarily focuses on summative assessment designed to record student achievement at, or towards the end of, the course of study. However, many of the assessment instruments can also be used formatively during the course of teaching and learning, and teachers are encouraged to do this. 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 Diploma Programme please refer to the publication *Diploma Programme assessment: Principles and practice*.

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

Markbands

Markbands are a comprehensive statement of expected performance against which responses are judged. They represent a single holistic criterion divided into level descriptors. Each level descriptor corresponds to a range of marks to differentiate student performance. A best-fit approach is used to ascertain which particular mark to use from the possible range for each level descriptor.

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.

Marking notes

For some assessment components marked using assessment criteria, marking notes are provided. Marking notes give guidance on how to apply assessment criteria to the particular requirements of a question.

Inclusive assessment arrangements

Inclusive assessment arrangements are available for candidates with assessment access requirements. These arrangements enable candidates with diverse needs to access the examinations and demonstrate their knowledge and understanding of the constructs being assessed.

The IB document *Candidates with assessment access requirements* provides details on all the inclusive assessment arrangements available to candidates with learning support requirements. The IB document *Learning diversity in the International Baccalaureate programmes: Special educational needs within the International Baccalaureate programmes* 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 IB documents *General regulations: Diploma Programme* and the *Handbook of procedures for the Diploma Programme* provide 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 *Candidates with assessment access requirements* and *Learning diversity in the International Baccalaureate programmes: Special educational needs within the International Baccalaureate programmes*.

Assessment outline—SL

First assessment 2018

Assessment component	Weighting
External assessment (3 hours)	**80%**
Paper 1 (45 minutes) Syllabus content: Core 30 multiple-choice questions on the core syllabus. Assessment objectives 1 and 2. (30 marks)	**20%**
Paper 2 (1 hour 15 minutes) Syllabus content: Core Section A: Students answer one data-based question and several short-answer questions on the core (all compulsory). (30 marks) Section B: Students answer one extended-response question on the core (from a choice of three). (20 marks) Assessment objectives 1–3. (50 marks)	**35%**
Paper 3 (1 hour) Syllabus content: Options Several short-answer questions (all compulsory) in each of the two options studied. Assessment objectives 1–3. (40 marks)	**25%**
Internal assessment/individual investigation (10 hours) (24 marks) Assessment objectives 1–4. This component is internally assessed by the teacher and externally moderated.	**20%**

Assessment outline—HL

First assessment 2018

Assessment component	Weighting
External assessment (4 hours 30 minutes)	**80%**
Paper 1 (1 hour) Syllabus content: Core and AHL 40 multiple-choice questions about 15 of which are common with SL. Assessment objectives 1 and 2. (40 marks)	**20%**
Paper 2 (2 hours 15 minutes) Syllabus content: Core and AHL Section A: Students answer one data-based question and several short-answer questions on the core and AHL (all compulsory). (50 marks) Section B: Students answer two extended-response questions on the core and AHL (from a choice of four). (40 marks) Assessment objectives 1–3. (Total 90 marks)	**35%**
Paper 3 (1 hour 15 minutes) Syllabus content: Options Several short-answer and extended-response questions (all compulsory) in each of the two options studied. Assessment objectives 1–3. (50 marks)	**25%**
Internal assessment/individual investigation (10 hours) (24 marks) Assessment objectives 1–4. This component is internally assessed by the teacher and externally moderated.	**20%**

External assessment

For papers 1, 2 and 3 there are markschemes. The markschemes are specific to each examination.

External assessment details—SL

The external assessment consists of three written papers and is worth 80% of the final assessment.

Paper 1

Duration: 45 minutes
Weighting: 20%
Paper 1 is made up of 30 multiple-choice questions that test knowledge of the core only. The questions are designed to be short, one- or two-stage problems that address objectives 1 and 2 (see the "Assessment objectives in practice" section). No marks are deducted for incorrect responses. Calculators are not permitted, but students are expected to carry out simple calculations.

Paper 2

Duration: 1 hour 15 minutes
Weighting: 35%
Paper 2 tests knowledge of the core only. The questions address objectives 1, 2 and 3, and the paper is divided into two sections.

In section A, there is a data-based question that requires students to analyse a given set of data. The remainder of section A is made up of short-answer questions.

In section B, students are required to answer one question from a choice of three. These extended-response questions may involve writing a number of paragraphs, solving a substantial problem or carrying out a substantial piece of analysis or evaluation.

A calculator is required for this paper. Further information on recommended, approved and prohibited calculators may be found in the *Handbook of procedures for the Diploma Programme*, the calculator forum and the sports, exercise and health science home page of the OCC.

Paper 3

Duration: 1 hour
Weighting: 25%
Paper 3 tests knowledge of the options and addresses objectives 1, 2 and 3. Students are required to answer several short-answer questions in each of the two options studied.

A calculator is required for this paper. Further information on recommended, approved and prohibited calculators may be found in the *Handbook of procedures for the Diploma Programme*, the calculator forum and the sports, exercise and health science home page of the OCC.

Note: Wherever possible, teachers should use, and encourage students to use, the Système International d'Unités (International System of Units—SI units).

External assessment details—HL

The external assessment consists of three written papers and is worth 80% of the final assessment.

Paper 1

Duration: 1 hour
Weighting: 20%

Paper 1 is made up of 40 multiple-choice questions that test knowledge of the core and AHL topics. Approximately 15 of the 40 questions will be common with the SL paper. The questions are designed to be short, one- or two-stage problems that address objectives 1 and 2 (see the "Assessment objectives in practice" section). No marks are deducted for incorrect responses. Calculators are not permitted, but students are expected to carry out simple calculations.

Paper 2

Duration: 2 hours 15 minutes
Weighting: 35%

Paper 2 tests knowledge of the core and AHL topics. The questions address objectives 1, 2 and 3, and the paper is divided into two sections.

In section A, there is a data-based question that requires students to analyse a given set of data. The remainder of section A is made up of short-answer questions.

In section B, students are required to answer two questions from a choice of four. These extended-response questions may involve writing a number of paragraphs, solving a substantial problem or carrying out a substantial piece of analysis or evaluation.

A calculator is required for this paper. Further information on recommended, approved and prohibited calculators may be found in the *Handbook of procedures for the Diploma Programme*, the calculator forum and the sports, exercise and health science home page of the OCC.

Paper 3

Duration: 1 hour 15 minutes
Weighting: 25%

Paper 3 tests knowledge of the options and addresses objectives 1, 2 and 3. Students are required to answer several short-answer and extended-response questions in each of the two options studied.

A calculator is required for this paper. Further information on recommended, approved and prohibited calculators may be found in the *Handbook of procedures for the Diploma Programme*, the calculator forum and the sports, exercise and health science home page of the OCC.

Note: Wherever possible, teachers should use, and encourage students to use, the Système International d'Unités (International System of Units—SI units).

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. This "Internal assessment" section of the guide should be read in conjunction with the "Internal assessment" section of the teacher support materials.

Guidance and authenticity

The work submitted for internal assessment must be the student's own. 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 IB animal experimentation policy and the SEHS course safety guidelines (see "Safety requirements and recommendations")
- 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 honesty, 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 his or her 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 honesty*, *The Diploma Programme: From principles into practice* and the relevant articles in *General regulations: Diploma Programme*.

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 extended essay.

Group work

Each investigation is an individual piece of work based on different data collected or measurements generated. Ideally, students should work on their own when collecting data. In some cases, data collected or measurements made can be from a group experiment, provided each student collected his or her own data or made his or her own measurements. In SEHS, in some cases, group data or measurements may be combined to provide enough for individual analysis. Even in this case, each student should have collected and recorded their own data and they should clearly indicate which data are theirs.

It should be made clear to students that all work connected with the investigation should be their own. It is therefore helpful if teachers try to encourage in students a sense of responsibility for their own learning so that they accept a degree of ownership and take pride in their own work.

Time allocation

Internal assessment is an integral part of the SEHS course, contributing 20% to the final assessment in the SL and the HL courses. 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 a total of approximately 10 hours of teaching time for both SL and HL 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

While teachers are responsible for following national or local guidelines, which may differ from country to country, attention should be given to the following guidelines, which were developed by The Laboratory Safety Institute (LSI). The guidelines are posted on both LSI's website (labsafetyinstitute.org/) and the website of the International Council of Associations for Science Education (ICASE) Safety Committee. (www.icaseonline.net/safety.html).

It is a basic responsibility of everyone involved to make safety and health an ongoing commitment. Any advice given will acknowledge the need to respect the local context, the varying educational and cultural traditions, the financial constraints and the legal systems of differing countries.

The Laboratory Safety Institute's Laboratory Safety Guidelines …

40 suggestions for a safer lab

Steps requiring minimal expense

1. Have a written health, safety and environmental affairs (HS&E) policy statement.
2. Organize a departmental HS&E committee of employees, management, faculty, staff and students that will meet regularly to discuss HS&E issues.
3. Develop an HS&E orientation for all new employees and students.
4. Encourage employees and students to care about their health and safety, and that of others.
5. Involve every employee and student in some aspect of the safety programme and give each specific responsibility.
6. Provide incentives to employees and students for safety performance.
7. Require all employees to read the appropriate safety manual. Require students to read the institution's laboratory safety rules. Have both groups sign a statement that they have done so, understand the contents, and agree to follow the procedures and practices. Keep these statements on file in the department office
8. Conduct periodic, unannounced laboratory inspections to identify and correct hazardous conditions and unsafe practices. Involve students and employees in simulated OSHA inspections.
9. Make learning how to be safe an integral and important part of science education, your work and your life.
10. Schedule regular departmental safety meetings for all students and employees to discuss the results of inspections and aspects of laboratory safety.
11. When conducting experiments with hazards or potential hazards, ask yourself these questions.
    - What are the hazards?
    - What are the worst possible things that could go wrong?
    - How will I deal with them?
    - What are the prudent practices, protective facilities and equipment necessary to minimize the risk of exposure to the hazards?
12. Require that all accidents (incidents) be reported, evaluated by the departmental safety committee, and discussed at departmental safety meetings.
13. Require every pre-lab/pre-experiment discussion to include consideration of the health and safety aspects.
14. Don't allow experiments to run unattended unless they are failsafe.
15. Forbid working alone in any laboratory and working without prior knowledge of a staff member.
16. Extend the safety programme beyond the laboratory to the automobile and the home.
17. Allow only minimum amounts of flammable liquids in each laboratory.
18. Forbid smoking, eating and drinking in the laboratory.
19. Do not allow food to be stored in chemical refrigerators.

20. Develop plans and conduct drills for dealing with emergencies such as fire, explosion, poisoning, chemical spill or vapour release, electric shock, bleeding and personal contamination.
21. Require good housekeeping practices in all work areas.
22. Display the phone numbers of the fire department, police department and local ambulance either on or immediately next to every phone.
23. Store acids and bases separately. Store fuels and oxidizers separately.
24. Maintain a chemical inventory to avoid purchasing unnecessary quantities of chemicals.
25. Use warning signs to designate particular hazards.
26. Develop specific work practices for individual experiments, such as those that should be conducted only in a ventilated hood or involve particularly hazardous materials. When possible, most hazardous experiments should be done in a hood.

Steps requiring moderate expense

27. Allocate a portion of the departmental budget to safety.
28. Require the use of appropriate eye protection at all times in laboratories and areas where chemicals are transported.
29. Provide adequate supplies of personal protective equipment—safety glasses, goggles, face shields, gloves, lab coats and bench-top shields.
30. Provide fire extinguishers, safety showers, eye wash fountains, first aid kits, fire blankets and fume hoods in each laboratory, and test or check monthly.
31. Provide guards on all vacuum pumps and secure all compressed gas cylinders.
32. Provide an appropriate supply of first aid equipment and instruction on its proper use.
33. Provide fireproof cabinets for storage of flammable chemicals.
34. Maintain a centrally located departmental safety library:
    - "Safety in School Science Labs", Clair Wood, 1994, Kaufman & Associates, 101 Oak Street, Wellesley, MA 02482
    - "The Laboratory Safety Pocket Guide", 1996, Genium Publisher, One Genium Plaza, Schnectady, NY
    - "Safety in Academic Chemistry Laboratories", ACS, 1155 Sixteenth Street NW, Washington, DC 20036
    - "Manual of Safety and Health Hazards in The School Science Laboratory", "Safety in the School Science Laboratory", "School Science Laboratories: A guide to Some Hazardous Substances", Council of State Science Supervisors (now available only from LSI)
    - "Handbook of Laboratory Safety", 4th Edition, CRC Press, 2000 Corporate Boulevard NW, Boca Raton, FL 33431
    - "Fire Protection Guide on Hazardous Materials", National Fire Protection Association, Batterymarch Park, Quincy, MA 02269
    - "Prudent Practices in the Laboratory: Handling and Disposal of Hazardous Chemicals", 2nd Edition, 1995
    - "Biosafety in the Laboratory", National Academy Press, 2101 Constitution Avenue, NW, Washington, DC 20418
    - "Learning By Accident", Volumes 1–3, 1997–2000, The Laboratory Safety Institute, Natick, MA 01760

      (All are available from LSI.)

35. Remove all electrical connections from inside chemical refrigerators and require magnetic closures.
36. Require grounded plugs on all electrical equipment and install ground fault interrupters (GFIs) where appropriate.
37. Label all chemicals to show the name of the material, the nature and degree of hazard, the appropriate precautions, and the name of the person responsible for the container.
38. Develop a programme for dating stored chemicals and for recertifying or discarding them after predetermined maximum periods of storage.
39. Develop a system for the legal, safe and ecologically acceptable disposal of chemical wastes.
40. Provide secure, adequately spaced, well-ventilated storage of chemicals.

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 levels 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 great extent; 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 recommended that the assessment criteria be made available to students.

Practical work and internal assessment

General introduction

The internal assessment requirements are the same for biology, chemistry, physics and SEHS. The internal assessment, worth 20% of the final assessment, consists of one scientific investigation. The individual investigation should cover a topic that is commensurate with the level of the course of study.

Student work is internally assessed by the teacher and externally moderated by the IB. The performance in internal assessment at both SL and HL is marked against common assessment criteria, with a total mark out of 24.

> **Note:** Any investigation that is to be used to assess students should be specifically designed to match the relevant assessment criteria.

The internal assessment task will be one scientific investigation taking about 10 hours and the write-up should be about 6–12 pages long. Investigations exceeding this length will be penalized in the communication criterion as lacking in conciseness.

The practical investigation, with generic criteria, will allow a wide range of practical activities satisfying the varying needs of biology, chemistry, physics and SEHS. The investigation addresses many of the learner profile attributes well. See the "Approaches to teaching and learning" section for further links.

The task produced should be complex and commensurate with the level of the course. It should require a purposeful research question and the scientific rationale for it. The marked exemplar material in the teacher support materials will demonstrate that the assessment will be rigorous and of the same standard as the assessment in the previous courses.

Some of the possible tasks include:

- a hands-on laboratory investigation
- manipulated or observational fieldwork
- using a spreadsheet for analysis and modelling
- extracting data from a database and analysing it graphically
- producing a hybrid of spreadsheet/database work with a traditional hands-on investigation
- using a simulation, provided it is interactive and open-ended.

Some tasks may consist of relevant and appropriate qualitative work combined with quantitative work.

The tasks include the traditional hands-on practical investigations as in the previous course. The depth of treatment required for hands-on practical investigations is unchanged from the previous internal assessment and will be shown in detail in the teacher support material. In addition, detailed assessment of specific aspects of hands-on practical work will be assessed in the written papers as detailed in the relevant topic(s) in the "Syllabus content" section of the guide.

The task will have the same assessment criteria for SL and HL. The five assessment criteria are personal engagement, exploration, analysis, evaluation and communication.

Internal assessment details

Internal assessment component

Duration: 10 hours
Weighting: 20%

- Individual investigation.
- This investigation covers assessment objectives 1, 2, 3 and 4.

Internal assessment criteria

The new assessment model uses five criteria to assess the final report of the individual investigation with the following raw marks and weightings assigned.

Personal engagement	Exploration	Analysis	Evaluation	Communication	Total
2 (8%)	6 (25%)	6 (25%)	6 (25%)	4 17%)	24 (100%)

Levels of performance are described using multiple indicators per level. In many cases the indicators occur together in a specific level, but not always. Also, not all indicators are always present. This means that a candidate can demonstrate performances that fit into different levels. To accommodate this, the IB assessment models use markbands and advise examiners and teachers to use a **best-fit approach** in deciding the appropriate mark for a particular criterion.

Teachers should read the guidance on using markbands in the section called "Using assessment criteria for internal assessment" before starting to mark. It is also essential to be fully acquainted with the marking of the exemplars in the teacher support material. The precise meaning of the command terms used in the criteria can be found in the glossary of the subject guide.

Personal engagement

This criterion assesses the extent to which the student engages with the exploration and makes it his or her own. Personal engagement may be recognized in different attributes and skills. These could include addressing personal interests or showing evidence of independent thinking, creativity or initiative in the designing, implementation or presentation of the investigation.

Mark	Descriptor
0	The student's report does not reach a standard described by the descriptors below.
1	The evidence of personal engagement with the exploration is limited with little independent thinking, initiative or creativity. The justification given for choosing the research question and/or the topic under investigation does not demonstrate **personal significance, interest or curiosity**. There is little evidence of **personal input and initiative** in the designing, implementation or presentation of the investigation.
2	The evidence of personal engagement with the exploration is clear with significant independent thinking, initiative or creativity. The justification given for choosing the research question and/or the topic under investigation demonstrates **personal significance, interest or curiosity**. There is evidence of **personal input and initiative** in the designing, implementation or presentation of the investigation.

Exploration

This criterion assesses the extent to which the student establishes the scientific context for the work, states a clear and focused research question and uses concepts and techniques appropriate to the Diploma Programme level. Where appropriate, this criterion also assesses awareness of safety, environmental and ethical considerations.

Mark	Descriptor
0	The student's report does not reach a standard described by the descriptors below.
1–2	The topic of the investigation is identified and a research question of some relevance is **stated but it is not focused**. The background information provided for the investigation is **superficial** or of limited relevance and does not aid the understanding of the context of the investigation. The methodology of the investigation is only appropriate to address the research question to a very limited extent since it takes into consideration few of the significant factors that may influence the relevance, reliability and sufficiency of the collected data. The report shows evidence of limited awareness of the significant **safety,** ethical or environmental issues that are **relevant to the methodology of the investigation***.

Mark	Descriptor
3–4	The topic of the investigation is identified and a relevant but not fully focused research question is described. The background information provided for the investigation is mainly appropriate and relevant and aids the understanding of the context of the investigation. The methodology of the investigation is mainly appropriate to address the research question but has limitations since it takes into consideration only some of the significant factors that may influence the relevance, reliability and sufficiency of the collected data. The report shows evidence of some awareness of the significant **safety**, ethical or environmental issues that are **relevant to the methodology of the investigation***.
5–6	The topic of the investigation is identified and a relevant and fully focused research question is clearly described. The background information provided for the investigation is entirely appropriate and relevant and enhances the understanding of the context of the investigation. The methodology of the investigation is highly appropriate to address the research question because it takes into consideration all, or nearly all, of the significant factors that may influence the relevance, reliability and sufficiency of the collected data. The report shows evidence of full awareness of the significant **safety,** ethical or environmental issues that are **relevant to the methodology of the investigation***.

* This indicator should only be applied when appropriate to the investigation. See exemplars in the teacher support material.

Analysis

This criterion assesses the extent to which the student's report provides evidence that the student has selected, recorded, processed and **interpreted** the data in ways that are relevant to the research question and can support a conclusion.

Mark	Descriptor
0	The student's report does not reach a standard described by the descriptors below.
1–2	The report includes **insufficient relevant** raw data to support a valid conclusion to the research question. Some **basic** data processing is carried out but is either too **inaccurate or too insufficient to lead to a valid** conclusion. The report shows evidence of little consideration of the impact of measurement uncertainty on the analysis. The processed data is incorrectly or insufficiently interpreted so that the conclusion is invalid or very incomplete.

Mark	Descriptor
3–4	The report includes relevant but incomplete quantitative and qualitative raw data that could support a simple or partially valid conclusion to the research question. Appropriate and sufficient data processing is carried out that could lead to a broadly valid conclusion but there are significant inaccuracies and inconsistencies in the processing. The report shows evidence of some consideration of the impact of measurement uncertainty on the analysis. The processed data is interpreted so that a broadly valid but incomplete or limited conclusion to the research question can be deduced.
5–6	The report includes sufficient relevant quantitative and qualitative raw data that could support a detailed and valid conclusion to the research question. Appropriate and sufficient data processing is carried out with **the accuracy** required to enable a conclusion to the research question to be drawn that is fully **consistent** with the experimental data. The report shows evidence of full and appropriate consideration of the impact of measurement uncertainty on the analysis. The processed data is correctly interpreted so that a completely valid and detailed conclusion to the research question can be deduced.

Evaluation

This criterion assesses the extent to which the student's report provides evidence of evaluation of the investigation and the results with regard to the research question and the accepted scientific context.

Mark	Descriptor
0	The student's report does not reach a standard described by the descriptors below.
1–2	A conclusion is **outlined** which is not relevant to the research question or is not supported by the data presented. The conclusion makes superficial comparison to the accepted scientific context. Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are **outlined** but are restricted to an **account** of **the practical** or procedural issues faced. The student has **outlined** very few realistic and relevant suggestions for the improvement and extension of the investigation.
3–4	A conclusion is described which is relevant to the research question and supported by the data presented. A conclusion is described which makes some relevant comparison to the accepted scientific context. Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are described and provide evidence of some awareness of the methodological issues* involved in establishing the conclusion. The student has described some realistic and relevant suggestions for the improvement and extension of the investigation.

Mark	Descriptor
5–6	A detailed conclusion is described and justified which is entirely relevant to the research question and fully supported by the data presented. A conclusion is correctly described and justified through relevant comparison to the accepted scientific context. Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are discussed and provide evidence of a clear understanding of the methodological issues* involved in establishing the conclusion. The student has discussed realistic and relevant suggestions for the improvement and extension of the investigation.

* See exemplars in the teacher support material for clarification.

Communication

This criterion assesses whether the investigation is presented and reported in a way that supports effective communication of the focus, process and outcomes.

Mark	Descriptor
0	The student's report does not reach a standard described by the descriptors below.
1–2	The presentation of the investigation is unclear, making it difficult to understand the focus, process and outcomes. The report is not well structured and is unclear: the necessary information on focus, process and outcomes is missing or is presented in an incoherent or disorganized way. The understanding of the focus, process and outcomes of the investigation is obscured by the presence of inappropriate or irrelevant information. There are many errors in the use of subject-specific terminology and conventions*.
3–4	The presentation of the investigation is clear. Any errors do not hamper understanding of the focus, process and outcomes. The report is well structured and clear: the necessary information on focus, process and outcomes is present and presented in a coherent way. The report is relevant and concise thereby facilitating a ready understanding of the focus, process and outcomes of the investigation. The use of subject-specific terminology and conventions is appropriate and correct. Any errors do not hamper understanding.

* For example, incorrect/missing labelling of graphs, tables, images; use of units, decimal places. For issues of referencing and citations refer to the "Academic honesty" section.

Rationale for practical work

Although the requirements for internal assessment are centred on the investigation, the different types of practical activities that a student may engage in serve other purposes, including:

- illustrating, teaching and reinforcing theoretical concepts
- developing an appreciation of the essential hands-on nature of much scientific work
- developing an appreciation of scientists' use of secondary data from databases
- developing an appreciation of scientists' use of modelling
- developing an appreciation of the benefits and limitations of scientific methodology.

Practical scheme of work

The practical scheme of work (PSOW) is the practical course planned by the teacher and acts as a summary of all the investigative activities carried out by a student. Students at SL and HL in the same subject may carry out some of the same investigations.

Syllabus coverage

The range of practical work carried out should reflect the breadth and depth of the subject syllabus at each level, but it is not necessary to carry out an investigation for every syllabus topic. However, all students must participate in the group 4 project and the internal assessment investigation.

Planning your practical scheme of work

Teachers are free to formulate their own practical schemes of work by choosing practical activities according to the requirements outlined. Their choices should be based on:

- subjects, levels and options taught
- the needs of their students
- available resources
- teaching styles.

Each scheme must include some complex experiments that make greater conceptual demands on students. A scheme made up entirely of simple experiments, such as ticking boxes or exercises involving filling in tables, will not provide an adequate range of experience for students.

Teachers are encouraged to use the OCC to share ideas about possible practical activities by joining in the discussion forums and adding resources in the subject home pages.

Flexibility

The practical programme is flexible enough to allow a wide variety of practical activities to be carried out. These could include:

- short labs or projects extending over several weeks
- computer simulations
- using databases for secondary data
- developing and using models

- data-gathering exercises such as questionnaires, user trials and surveys
- data-analysis exercises
- fieldwork.

Practical work documentation

The *4/PSOW* form is a record of all practical activities carried out by a class. The form is not required to moderate the individual investigations, so it is not necessary to submit this form. However, the *4/PSOW* is an essential planning and recording document for teachers to ensure that a suitable range of practical activities is carried out and that the appropriate hours are allocated to practical work. Teachers should continue to maintain this form (or their own version of it including all the same information) to record the practical activities carried out by the class. The form should be retained in the school and made available to the IB, for example, during the five-year school evaluation process.

Time allocation for practical work

The recommended teaching times for all Diploma Programme courses are 150 hours at SL and 240 hours at HL. Students at SL are required to spend 40 hours, and students at HL 60 hours, on practical activities (excluding time spent writing up work). These times include 10 hours for the group 4 project and 10 hours for the internal assessment investigation. (Only 2–3 hours of investigative work can be carried out after the deadline for submitting work to the moderator and still be counted in the total number of hours for the practical scheme of work.)

The group 4 project

The group 4 project is an interdisciplinary activity in which all Diploma Programme science students must participate. The intention is that students from the different group 4 subjects analyse a common topic or problem. The exercise should be a collaborative experience where the emphasis is on the processes involved in, rather than the products of, such an activity.

In most cases, students in a school would be involved in the investigation of the same topic. Where there are large numbers of students, it is possible to divide them into several smaller groups containing representatives from each of the science subjects. Each group may investigate the same topic or different topics—that is, there may be several group 4 projects in the same school.

Students studying environmental systems and societies are not required to undertake the group 4 project.

Summary of the group 4 project

The group 4 project is a collaborative activity where students from different group 4 subjects work together on a scientific or technological topic, allowing for concepts and perceptions from across the disciplines to be shared in line with aim 10—that is, to "develop an understanding of the relationships between scientific disciplines and their influence on other areas of knowledge". The project can be practically or theoretically based. Collaboration between schools in different regions is encouraged.

The group 4 project allows students to appreciate the environmental, social and ethical implications of science and technology. It may also allow them to understand the limitations of scientific study, for example, the shortage of appropriate data and/or the lack of resources. The emphasis is on interdisciplinary cooperation and the processes involved in scientific investigation, rather than the products of such investigation.

The choice of scientific or technological topic is open but the project should clearly address aims 7, 8 and 10 of the SEHS subject guide.

Ideally, the project should involve students collaborating with those from other group 4 subjects at all stages. To this end, it is not necessary for the topic chosen to have clearly identifiable separate subject components. However, for logistical reasons, some schools may prefer a separate subject "action" phase (see the following "Project stages" section).

Project stages

The 10 hours allocated to the group 4 project, which are part of the teaching time set aside for developing the practical scheme of work, can be divided into three stages: planning, action and evaluation.

Planning

This stage is crucial to the whole exercise and should last about two hours.

- The planning stage could consist of a single session, or two or three shorter ones.
- This stage must involve all group 4 students meeting to "brainstorm" and discuss the central topic, sharing ideas and information.
- The topic can be chosen by the students themselves or selected by the teachers.
- Where large numbers of students are involved, it may be advisable to have more than one mixed-subject group.

After selecting a topic or issue, the activities to be carried out must be clearly defined before moving from the planning stage to the action and evaluation stages.

A possible strategy is that students define specific tasks for themselves, either individually or as members of groups, and investigate various aspects of the chosen topic. At this stage, if the project is to be experimentally based, apparatus should be specified so that there is no delay in carrying out the action stage. Contact with other schools, if a joint venture has been agreed, is an important consideration at this time.

Action

This stage should last around six hours and may be carried out over one or two weeks in normal scheduled class time. Alternatively, a whole day could be set aside if, for example, the project involves fieldwork.

- Students should investigate the topic in mixed-subject groups or single-subject groups.
- There should be collaboration during the action stage; findings of investigations should be shared with other students within the mixed-/single-subject group. During this stage, in any practically based activity, it is important to pay attention to safety, ethical and environmental considerations.

> **Note:** Students studying two group 4 subjects are not required to do two separate action phases.

Evaluation

The emphasis during this stage, for which two hours are probably necessary, is on students sharing their findings, both successes and failures, with other students. How this is achieved can be decided by the teachers, the students or jointly.

- One solution is to devote a morning, afternoon or evening to a symposium where all the students, as individuals or as groups, give brief presentations.
- Alternatively, the presentation could be more informal and take the form of a science fair where students circulate around displays summarizing the activities of each group.

The symposium or science fair could also be attended by parents, members of the school board and the press. This would be especially pertinent if some issue of local importance has been researched. Some of the findings might influence the way the school interacts with its environment or local community.

Addressing aims 7 and 8

Aim 7: "develop and apply 21st-century communication skills in the study of science".

Aim 7 may be partly addressed at the planning stage by using electronic communication within and between schools. It may be that technology (for example, data logging, spreadsheets, databases and so on) will be used in the action phase and certainly in the presentation/evaluation stage (for example, use of digital images, presentation software, websites, digital video and so on).

Aim 8: "become critically aware, as global citizens, of the ethical implications of using science and technology".

Addressing the international dimension

There are also possibilities in the choice of topic to illustrate the international nature of the scientific endeavour and the increasing cooperation required to tackle global issues involving science and technology. An alternative way to bring an international dimension to the project is to collaborate with a school in another region.

Types of project

While addressing aims 7, 8 and 10, the project must be based on science or its applications. The project may have a hands-on practical action phase or one involving purely theoretical aspects. It could be undertaken in a wide range of ways, such as:

- designing and carrying out a laboratory investigation or fieldwork
- carrying out a comparative study (experimental or otherwise) in collaboration with another school
- collating, manipulating and analysing data from other sources, such as scientific journals, environmental organizations, science and technology industries and government reports
- designing and using a model or simulation
- contributing to a long-term project organized by the school.

Logistical strategies

The logistical organization of the group 4 project is often a challenge to schools. The following models illustrate possible ways in which the project may be implemented.

Models A, B and C apply within a single school, and model D relates to a project involving collaboration between schools.

Model A: Mixed-subject groups and one topic

Schools may adopt mixed-subject groups and choose one common topic. The number of groups will depend on the number of students.

Model B: Mixed-subject groups adopting more than one topic

Schools with large numbers of students may choose to do more than one topic.

Model C: Single-subject groups

For logistical reasons, some schools may opt for single-subject groups, with one or more topics in the action phase. This model is less desirable as it does not show the mixed-subject collaboration in which many scientists are involved.

Model D: Collaboration with another school

The collaborative model is open to any school. To this end, the IB provides an electronic collaboration board on the OCC where schools can post their project ideas and invite collaboration from other schools. This could range from merely sharing evaluations for a common topic to a full-scale collaborative venture at all stages.

For schools with few Diploma Programme students or schools with Diploma Programme course students, it is possible to work with non-Diploma Programme or non-group 4 students or undertake the project once every two years. However, these schools are encouraged to collaborate with another school. This strategy is also recommended for individual students who may not have participated in the project, for example, through illness or because they have transferred to a new school where the project has already taken place.

Timing

The 10 hours that the IB recommends be allocated to the project may be spread over a number of weeks. The distribution of these hours needs to be taken into account when selecting the optimum time to carry out the project. However, it is possible for a group to dedicate a period of time exclusively to project work if all/most other schoolwork is suspended.

Year 1

In the first year, students' experience and skills may be limited and it would be inadvisable to start the project too soon in the course. However, doing the project in the final part of the first year may have the advantage of reducing pressure on students later on. This strategy provides time for solving unexpected problems.

Year 1–Year 2

The planning stage could start, the topic could be decided upon, and provisional discussion in individual subjects could take place at the end of the first year. Students could then use the vacation time to think about how they are going to tackle the project and would be ready to start work early in the second year.

Year 2

Delaying the start of the project until some point in the second year, particularly if left too late, increases pressure on students in many ways: the schedule for finishing the work is much tighter than for the other options; the illness of any student or unexpected problems will present extra difficulties. Nevertheless, this choice does mean students know one another and their teachers by this time, have probably become accustomed to working in a team and will be more experienced in the relevant fields than in the first year.

Combined SL and HL

Where circumstances dictate that the project is only carried out every two years, HL beginners and more experienced SL students can be combined.

Selecting a topic

Students may choose the topic, or propose possible topics, and the teacher then decides which one is the most viable based on resources, staff availability and so on. Alternatively, the teacher selects the topic or proposes several topics from which students make a choice.

Student selection

Students are likely to display more enthusiasm and feel a greater sense of ownership for a topic that they have chosen themselves. A possible strategy for student selection of a topic, which also includes part of the planning stage, is outlined here. At this point, subject teachers may provide advice on the viability of proposed topics.

- Identify possible topics by using a questionnaire or a survey of students.
- Conduct an initial "brainstorming" session of potential topics or issues.
- Discuss, briefly, two or three topics that seem interesting.
- Select one topic by consensus.
- Students make a list of potential investigations that could be carried out. All students then discuss issues such as possible overlap and collaborative investigations.

A reflective statement written by each student on their involvement in the group 4 project must be included on the coversheet for each internal assessment investigation. See *Handbook of procedures for the Diploma Programme* for more details.

Glossary of command terms

Command terms for SEHS

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.

Assessment objective 1

Define	Give the precise meaning of a word, phrase, concept or physical quantity.
Draw	Represent by means of a labelled, accurate diagram or graph, using a pencil. A ruler (straight edge) should be used for straight lines. Diagrams should be drawn to scale. Graphs should have points correctly plotted (if appropriate) and joined in a straight line or a smooth curve.
Label	Add labels to a diagram.
List	Give a sequence of brief answers with no explanation.
Measure	Obtain a value for a quantity.
State	Give a specific name, value or other brief answer without explanation or calculation.

Assessment objective 2

Annotate	Add brief notes to a diagram or graph.
Apply	Use an idea, equation, principle, theory or law in relation to a given problem or issue.
Calculate	Obtain a numerical answer showing the relevant stages in the working.
Describe	Give a detailed account.
Distinguish	Make clear the differences between two or more concepts or items.
Estimate	Obtain an approximate value.
Identify	Provide an answer from a number of possibilities.
Outline	Give a brief account or summary.

Assessment objective 3

Analyse	Break down in order to bring out the essential elements or structure.
Comment	Give a judgment based on a given statement or result of a calculation.
Compare	Give an account of similarities between two (or more) items or situations, referring to both (all) of them throughout.
Compare and Contrast	Give an account of similarities and differences between two (or more) items or situations, referring to both (all) of them throughout.
Construct	Display information in a diagrammatic or logical form.
Deduce	Reach a conclusion from the information given.
Derive	Manipulate a mathematical relationship to give a new equation or relationship.
Design	Produce a plan, simulation or model.
Determine	Obtain the only possible answer.
Discuss	Offer a considered and balanced review that includes a range of arguments, factors or hypotheses. Opinions or conclusions should be presented clearly and supported by appropriate evidence.
Evaluate	Make an appraisal by weighing up the strengths and limitations.
Explain	Give a detailed account including reasons or causes.
Predict	Give an expected result.
Show	Give the steps in a calculation or derivation.
Sketch	Represent by means of a diagram or graph (labelled as appropriate). The sketch should give a general idea of the required shape or relationship, and should include relevant features.
Solve	Obtain the answer(s) using algebraic and/or numerical and/or graphical methods.
Suggest	Propose a solution, hypothesis or other possible answer.

Bibliography

This bibliography lists the principal 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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