

INTERNATIONAL BACCALAUREATE ORGANIZATION

ECOSYSTEMS AND SOCIETIES
(Standard Level)

Modified Version June 2005

Ecosystems and Societies

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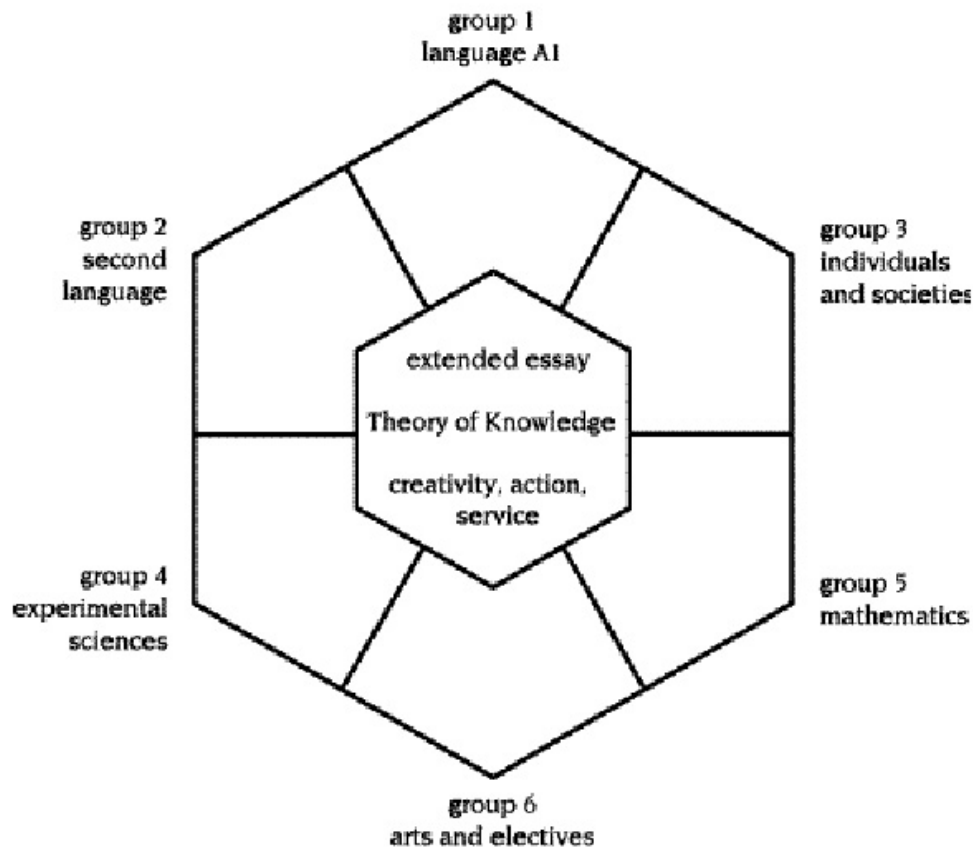
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PART I – CURRICULUM DETAILS

INTRODUCTION

The International Baccalaureate Diploma Programme is a rigorous pre-university course of studies, leading to examinations, that meets the needs of highly motivated secondary school students between the ages of 16 and 19 years. Designed as a comprehensive two-year curriculum that allows its graduates to fulfill requirements of various national education systems, the Diploma Programme model is based on the pattern of no single country but incorporates the best elements of many. The programme is available in English, French and Spanish.

The curriculum is displayed in the shape of a hexagon with six academic areas surrounding the core. Subjects are studied concurrently and students are exposed to the two great traditions of learning: the humanities and the sciences.



Diploma Programme candidates are required to select one subject from each of the six subject groups. At least three and not more than four are taken at higher level (HL), the others at standard level (SL). Higher level courses represent 240 teaching hours; standard level courses cover 150 hours. By

arranging work in this fashion, students are able to explore some subjects in depth and some more broadly over the two-year period; this is a deliberate compromise between the early specialization preferred in some national systems and the breadth found in others.

Distribution requirements ensure that the science-orientated student is challenged to learn a foreign language and that the natural linguist becomes familiar with science laboratory procedures. While overall balance is maintained, flexibility in choosing higher level combinations allows the student to pursue areas of personal interest and to meet special requirements for university entrance.

Successful Diploma Programme candidates meet three requirements in addition to the six subjects. The interdisciplinary Theory of Knowledge (TOK) course is designed to develop a coherent approach to learning which transcends and unifies the academic areas and encourages appreciation of other cultural perspectives. The extended essay of some 4000 words offers the opportunity to investigate a topic of special interest and acquaints students with the independent research and writing skills expected at university. Participation in the creativity, action, service (CAS) requirement encourages students to be involved in artistic pursuits, sports and community service work.

For first examinations in 2006

CURRICULUM MODEL

Ecosystems and societies is a Diploma Programme pilot course which is available at standard level (SL) only. Students are required to spend 120 hours studying the material specified in the course and a further 30 hours on practical/investigative work.

Format of the Syllabus Details

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 of the syllabus details section of the guide is as follows.

Topics

Topics are numbered (e.g. Topic 4: Conservation and Biodiversity).

Sub-topics

Sub-topics are numbered and the estimated teaching time required to cover the material is indicated (e.g. 4.1 Biodiversity in Ecosystems (3h)). The times are for guidance only and do not include time for practical/investigative work.

Assessment statements (A.S.)

Assessment statements, which are numbered, are expressed in terms of the outcomes that are expected of students at the end of the course (e.g. 4.1.2 Outline the mechanism of natural selection as a possible driving force for speciation). These statements are intended to prescribe to examiners what can be assessed by means of the written examinations. Each statement is classified as objective 1, 2 or 3 (see page 6) according to the action verb(s) used (see page 7). The objective levels are relevant for the examinations and for balance within the syllabus, and the action verbs indicate the depth of treatment required for a given assessment statement. It is important that students are made aware of the meanings of the action verbs since these will be used in examination questions.

Teacher's notes

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

Topic 4: Conservation and Biodiversity		
A.S.		Obj
	4.1 Biodiversity in Ecosystems (3h)	
4.1.1	Define the terms <i>biodiversity</i> , <i>genetic diversity</i> , <i>species diversity</i> and <i>habitat diversity</i> .	1
4.1.2	Outline the mechanism of natural selection as a possible driving force for speciation. Speciation occurs as a result of the isolation (geographical or reproductive) of populations. The concept of fitness should be understood. The history of the development of the modern theory of evolution is not expected, neither is a detailed knowledge of genetics (including allele frequency).	2

AIMS

The systems approach provides the core methodology of this course. It is amplified by other methodologies such as economic, historical, cultural, socio-political and scientific, to provide a holistic perspective on environmental issues.

The aims of this course are to:

1. promote understanding of environmental processes at a variety of scales, from local to global
2. provide a body of knowledge, methodologies and skills which can be used in the analysis of environmental issues at local and global levels
3. enable students to apply the knowledge, methodologies and skills gained
4. promote critical awareness of a diversity of cultural perspectives
5. recognize the extent to which technology plays a role in both causing and solving environmental problems
6. appreciate the value of local as well as international collaboration in resolving environmental problems
7. appreciate that environmental issues may be controversial, and may provoke a variety of responses
8. appreciate that human society is both directly and indirectly linked to the environment at a number of levels and at a variety of scales

OBJECTIVES

The objectives reflect those parts of the aims that will be assessed. It is the intention of this course that students should achieve the following objectives.

1. Demonstrate an understanding of information, terminology, concepts, methodologies and skills with regard to environmental issues.
2. Apply and use information, terminology, concepts, methodologies and skills with regard to environmental issues.
3. Synthesize, analyse and evaluate research questions, hypotheses, methods and scientific explanations with regard to environmental issues.
4. Using a holistic approach, make reasoned and balanced judgments using appropriate economic, historical, cultural socio-political and scientific methodologies.
5. Articulate and justify a personal viewpoint on environmental issues with reasoned argument while appreciating alternative viewpoints, including the perceptions of different cultures.
6. Demonstrate the personal skills of cooperation, perseverance and responsibility appropriate for effective investigation and problem solving.
7. Select and demonstrate the appropriate practical and research skills necessary to carry out investigations with due regard to precision, ethics and safety.

ACTION VERBS

These action verbs indicate the depth of treatment required for a given assessment statement and relate to the course objectives on page 7. Objectives 1 and 2 are lower order skills and objectives 3, 4 and 5 relate to higher order skills. These verbs will be used in examination questions and so it is important that students are familiar with the following definitions.

Objective 1

Define	give the precise meaning of a word or phrase as concisely as possible
Draw	represent by means of pencil lines (add labels unless told not to do so)
List	give a sequence of names or other brief answers with no elaboration, each one clearly separated from the others
Measure	find a value for a quantity
State	give a specific name, value or other brief answer (no supporting argument or calculation is necessary)

Objective 2

Annotate	add brief notes to a diagram, drawing or graph
Apply	use an idea, equation, principle, theory or law in a new situation
Calculate	find an answer using mathematical methods (show the working unless instructed not to do so)
Compare	give an account of similarities and differences between two (or more) items, referring to both (all) of them throughout (comparisons can be given using a table)
Describe	give a detailed account, including all the relevant information
Distinguish	give the differences between two or more different items
Estimate	find an approximate value for an unknown quantity, based on the information provided and scientific knowledge
Identify	find an answer from a number of possibilities
Outline	give a brief account or summary (include essential information only)

Objectives 3, 4 and 5

Analyse	interpret data to reach conclusions
Construct	represent or develop in graphical form
Deduce	reach a conclusion from the information given
Derive	manipulate a mathematical equation to give a new equation or result
Design	produce a plan, object, simulation or model
Determine	find the only possible answer
Discuss	give an account including, where possible, a range of arguments, assessments of the relative importance of various factors or comparisons of alternative hypotheses
Evaluate	assess the strengths, limitations and implications
Explain	give a clear account including causes, reasons or mechanisms
Justify	defend a viewpoint with reasoned argument
Predict	give an expected result
Solve	obtain an answer using algebraic and/or numerical methods
Suggest	propose a hypothesis or other possible answer

EXTERNAL ASSESSMENT

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

A calculator is required for both papers. Programmable graphic display calculators (GDCs) are permitted.

Paper 1

Paper 1 is made up of short-answer and data response questions which address objectives 1, 2 and 3.

Paper 2

Paper 2 consists of two sections, A and B, and the questions address objectives 1 to 5.

In section A, students will be provided with a range of data in a variety of forms relating to a specific case study. Students are required to make reasoned and balanced judgments by analysing this data

In section B, students are required to answer two structured essay questions from a choice of four.

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

Assessment Specifications

Component	Overall Weighting (%)	Duration (hours)	Format
Paper 1	30	1	short-answer and data response
Paper 2	50	2	Section A: case study Section B: two structured essay questions (from a choice of four)

INTERNAL ASSESSMENT

General Introduction

The internal assessment (IA) consists of fieldwork/practical work and is worth 20% of the final assessment. Internal assessment addresses objectives 6 and 7 in particular, but also objectives 1 to 5 (see page 6).

Student work is internally assessed by the teacher and externally moderated by the IBO. The performance in IA is judged against four assessment criteria (see page 14).

The single most important aspect of the ecosystems and societies 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.

The better practical scheme of work will be one that moves toward the holistic modelling of particular environments rather than using a series of isolated ecological exercises. If several techniques are employed to measure various components of a single ecosystem, the interrelatedness of these components can be examined and the final result may be a more integrated and holistic model.

Rationale for Practical Work

Although the requirements for IA are mainly centred on the assessment of research and practical skills, the different types of experimental work 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 fieldwork
- developing an appreciation of the benefits and limitations of a range of investigative methodologies.

Therefore, there may be good justification for teachers to conduct further experimental work beyond that required for the IA scheme.

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. Where more than one group of students is taught in a school, common investigations are acceptable.

Syllabus Coverage

The range of investigations carried out should reflect the breadth and depth of the syllabus, but it is not necessary to carry out an investigation for every syllabus topic. However, IA activities should ideally include a spread of content material from the course. A minimum number of investigations to be carried out is not specified.

Choosing Investigations

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

- the needs of their students
- available resources
- teaching styles.

Each scheme of work must include at least a few complex investigations that make greater conceptual demands on the students. Given the aims and objectives of this course, students should be provided with the opportunity to carry out investigations that demonstrate the interrelationships between ecological and social systems. 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.

Note: Any investigation or part investigation that is to be used to assess candidates should be specifically designed to match the relevant assessment criteria.

Flexibility

The IA model is flexible enough to allow a wide variety of investigations to be carried out. These could include:

- short laboratory practicals over one or two lessons and long-term practicals or projects extending over several weeks
- computer simulations
- data-gathering exercises such as questionnaires and surveys
- data analysis exercises
- general laboratory work and fieldwork.

It is vital, however, that the range of tasks undertaken by students reflects the transdisciplinary nature of this course. Through a balanced and varied PSOW students should be able to experience tasks which focus on lab/fieldwork, as well as more value-based investigations.

Practical Work Documentation

Details of an individual student's practical scheme of work are recorded on **form ES/PSOW** (see page 72). Electronic versions of this form may be used as long as they include all necessary information.

Internal Assessment Time Allocation

The recommended teaching time for Diploma Programme courses at standard level is 150 hours. Standard level students are required to spend 30 hours on IA activities (excluding time spent writing up investigations and fieldwork). The time allocated to IA activities should be spread throughout most of the course and not confined to just a few weeks at the beginning, middle or end.

Guidance and Authenticity

All candidates should be familiar with the requirements for IA. It should be made clear to them that they are entirely responsible for their own work. It is helpful if teachers encourage candidates to develop a sense of responsibility for their own learning so that they accept a degree of ownership and take pride in their own work. In responding to specific questions from candidates concerning investigations, teachers should (where appropriate) guide candidates into more productive routes of inquiry rather than respond with a direct answer.

When completing an investigation outside the classroom candidates should work independently where possible. Teachers are required to ensure that work submitted is the candidate's own. If in doubt, authenticity may be checked by one or more of the following methods:

- discussion with the candidate
- asking the candidate to explain the methods used and to summarize the results
- asking the candidate to repeat the investigation.

Safety

While teachers are responsible for following national or local guidelines which may differ from country to country, attention should be given to the mission statement overleaf which was developed by the International Council of Associations for Science Education (ICASE) Safety Committee.

ICASE Safety Committee

Mission Statement

The mission of the ICASE Safety Committee is to promote good quality, exciting practical science, which will stimulate students and motivate their teachers, in a safe and healthy learning environment. In this way, all individuals (teachers, students, laboratory assistants, supervisors, visitors) involved in science education are entitled to work under the safest possible practicable conditions in science classrooms and laboratories. Every reasonable effort needs to be made by administrators to provide and maintain a safe and healthy learning environment and to establish and require safe methods and practices at all times. Safety rules and regulations need to be developed and enforced for the protection of those individuals carrying out their activities in science classrooms and laboratories, and experiences in the field. Alternative science activities are encouraged in the absence of sufficiently safe conditions.

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.

Criteria and Aspects

There are four assessment criteria which are used to assess the work of candidates:

- *Planning*—PI
- *data collection and processing*—DCP
- *discussion, evaluation and conclusion*—DEC
- *personal skills*—PS

Each candidate must be assessed at least twice on each of the first three criteria. The criterion *personal skills* is assessed **summatively** once only at the end of the course. This summative judgement takes into account the candidate's performance over several pieces of work. It should:

- not be the average achieved over the whole practical scheme of work
- reflect any sustained improvement in performance.

The highest two levels achieved for each of the first three criteria are added to the level achieved for *personal skills*, to determine the final mark out of 42 for the IA component. This will then be scaled at IBCA to give a total out of 20%. (See section 3 for information concerning submission of IA work to the moderator.)

Each of the assessment criteria is separated into three **aspects** as shown on the following pages. Descriptions are provided to indicate what is expected in order to meet the requirements of a given aspect **completely (c)** and **partially (p)**. A description is also given for circumstances in which the requirements are not satisfied, **not at all (n)**.

Planning

	ASPECTS		
LEVELS	Defining the problem and selecting variables	Designing a method for the control of variables	Describing a method for collection of sufficient relevant data
Complete	States a focused problem/research question and identifies the relevant variables.	Designs a method for the control of variables.	Describes a method that allows for the collection of sufficient relevant data.
Partial	States a problem/research question that is incomplete or identifies only some relevant variables.	Designs a method that makes some attempt to control the variables.	Describes a method that does not allow for the collection of sufficient relevant data.
Not at all	Does not state a problem/research question and does not identify any relevant variables.	Designs a method that does not allow for the control of the variables.	Describes a method that does not allow for the collection of any relevant data.

Data Collection and Processing

	ASPECTS		
LEVELS	Collecting data	Processing data	Presenting processed data
Complete	Systematically collects appropriate quantitative and qualitative data*, including units.	Processes the quantitative primary and/or secondary data correctly.	Presents processed data appropriately and effectively to assist analysis.
Partial	Collects appropriate quantitative and qualitative data but with some mistakes and/or omissions.	Processes the quantitative primary and/or secondary data but with some mistakes and/or omissions.	Presents processed data appropriately but lacks clarity or with some mistakes and/or omissions.
Not at all	Data is not collected or is recorded incomprehensibly.	No processing of data is carried out or major mistakes are made in processing.	Presents processed data inappropriately or incomprehensibly.

* This can be raw primary data or secondary data.

Discussion, Evaluation and Conclusion

	ASPECTS		
LEVELS	Discussing and reviewing	Evaluating procedure(s) and suggesting improvements	Concluding
Complete	Discussion is clear and well reasoned, showing a broad understanding of context and the implications of results.	Identifies weaknesses and limitations and suggests realistic improvements.	States a reasonable conclusion, with a correct explanation, based on the data.
Partial	Discussion is adequate, showing some understanding of context and implications of results.	Identifies weaknesses and limitations but misses some obvious faults. Suggests only superficial improvements.	States a reasonable conclusion or gives a correct explanation, based on the data.
Not at all	Discussion is inadequate, showing little understanding of context and implications of results.	The weaknesses and limitations are irrelevant or missing. Suggests unrealistic improvements.	States an unreasonable conclusion or no conclusion at all.

Personal Skills

	ASPECTS		
LEVELS	Carrying out techniques	Working in a team	Working safely and ethically
Complete	Fully competent and methodical in the use of a range of techniques and equipment.	Consistently collaborates and communicates in a group situation and integrates the views of others.	Always pays attention to safety issues and shows due regard for environmental consequences of their actions and academic integrity.
Partial	Usually competent and methodical in the use of a range of techniques and equipment.	Occasionally collaborates and communicates in a group situation.	Usually pays attention to safety issues and shows some regard for environmental consequences of their actions and academic integrity.
Not at all	Rarely competent and methodical in the use of a range of techniques and equipment.	Makes little/no attempt to collaborate in a group situation.	Pays little attention to safety issues and shows little regard for environmental consequences of their actions and academic integrity.

This criterion must be assessed **summatively**.

Achievement Level Matrix

For a particular criterion, a piece of work is judged to see whether the requirements of each aspect have been fulfilled completely, partially or not at all. This can then be translated into a level 0 to 6 using the achievement level matrix below. The lowest level of achievement is represented by 0, and 6 represents the highest level of achievement.

		Aspects		
		A	B	C
Level				
Completely		2	2	2
Partially		1	1	1
Not at all		0	0	0

Assessing an Investigation

In assessing an investigation it must be noted that:

- level 6 does not imply faultless performance
- only whole numbers should be awarded, not fractions or decimals.

The work being assessed must be that of the student. For example in work on *data collection and processing*, the student should collect the data, process the data and present the processed data; information as to how this is to be done should not be provided by the teacher. This principle extends to the other criteria.

To illustrate the use of the achievement level matrix above, consider the following example. A student's work is assessed against the criterion *planning*. The teacher feels that the first aspect, *defining the problem and selecting variables*, is met completely whereas the second and third aspects, *designing a method for the control of variables* and *describing a method for collection of sufficient relevant data* are only achieved partially. Using the matrix, this translates to a level of 4.

Guidance on the Criteria

Planning

It is essential in order to assess this criterion that students are given an open-ended problem to investigate. Although the teacher may provide a general aim or context, students must individually identify a problem or research question for themselves. For example, the teacher might suggest that students select and investigate a pattern of distribution in a given ecosystem. Students may decide to investigate a species, identify a particular pattern, formulate a relevant research question, identify those variables that may be responsible for the pattern and design a method for collecting data.

Defining the problem and selecting variables

The problem or research question must be clearly stated by the student, possibly in the form of a hypothesis. The student must also clearly state the relevant variables in the investigation, including those to be measured and those to be controlled.

Designing a method for the control of variables

It is recognized that in fieldwork in particular, not all variables can be controlled but the student should nevertheless clearly identify such variables and attempt to minimize their influence where possible.

Describing a method for collection of sufficient relevant data

The method should allow for the collection of sufficient relevant data to answer the research question. However, what is considered “sufficient” will depend upon the nature of the investigation and the time available to the student.

For the purposes of assessing the planning criterion, it is not necessary that the student actually carries out the investigation but written accounts should be sufficient to provide evidence of all aspects being assessed. Ideally however, student-planned investigations should be implemented rather than be treated as a theoretical exercise.

Data Collection and Processing

The collection and processing of primary and secondary environmental data is an integral part of enhancing students’ understanding of the interaction between society and the environment. Investigations based on either primary or secondary data can be assessed here.

Collecting data

Data may be quantitative or qualitative and may consist of numerical measurements, observations, drawings, maps, photographs, results of questionnaires or interviews.

Primary data may be generated through fieldwork, laboratory investigations or surveys. Use of secondary data may be the only way to investigate some topics effectively, but in this situation it is **essential** that students select the relevant data for themselves from a range of secondary sources which may or may not be provided by the teacher. If the data is selected for the students, no credit can be awarded for this aspect of the criterion.

A student who systematically collects relevant data and records it clearly, (eg a well-designed table with correct units and consistent significant figures) would have fulfilled this aspect completely. A student who collects relevant data, but uses incorrect units, omits units or uses inconsistent or inappropriate significant figures would have partially fulfilled this aspect. A student who collected little or no data and whose results are difficult or impossible to comprehend because of the way in which they are laid out, would not have fulfilled this aspect at all.

Processing data

Processing data refers to the manipulation of raw data before it is finally presented. In order to assess this criterion it is important to use an investigation that requires data processing. This might include grouping elements from raw data, calculation of mean values, percentages, indices or statistical tests. For example, students may collect raw data from communities along a transect and process this data to provide diversity indices for each point, which can subsequently be presented on a graph. Alternatively the results of an open-ended questionnaire on perceptions of global warming may be grouped into common elements so that percentages for each group can be calculated.

It is important in assessing this criterion that students are given the opportunity to select their own methods of processing the data. The written account must include evidence of this processing, eg. calculations for a diversity index, or tabulation of open-ended questionnaire data ready for graphical presentation.

Presenting processed data

The emphasis is on selection of a method of presentation that displays the processed data to best effect and aids interpretation. Presentation of data may take many forms, including graphical models such as kite diagrams, maps, charts, flow diagrams or annotated drawings.

A high level of neatness and precision, use of scientific conventions and inclusion of unambiguous headings and labels contribute to effective presentation.

Unnecessary repetitive presentation of the same data set in a variety of formats is inappropriate.

Discussion, Evaluation and Conclusion

Once the data has been processed and presented in a suitable form, the results are discussed and reviewed, procedures are evaluated and conclusions are drawn. It is intended that this criterion should reflect the holistic approach that is central to the ethos of this course. Thus in the process of reviewing, evaluating and concluding, the student should demonstrate an ability to coherently discuss the broader significance of their findings.

Discussing and reviewing

In the discussion, students should review their results and consider them in the light of accepted scientific understanding.

Evaluating procedure(s) and suggesting improvements

Students should evaluate their investigation in a constructive and reflective way, recognizing strengths but also using weaknesses and limitations to suggest realistic improvements. Students may consider procedures, limitations of equipment, use of equipment, management of time, investigation timing, data quality (accuracy and precision) and relevance of data.

Concluding

Students are expected to provide a concise and clear conclusion which is supported by the evidence from the data and their discussion.

Personal Skills

This criterion is assessed **summatively** once only at the end of the course.

Carrying out techniques

The effective student should be able to carry out a range of techniques competently, follow instructions, and assemble and use equipment with precision and accuracy.

Working in a team

Working in a team is when two or more students work on a task collaboratively. Effective teamwork includes recognizing the contribution of others. There is an expectation that all team members contribute and are encouraged to contribute by the rest of the team. This will be demonstrated in the exchange of ideas, and an ability to integrate ideas into decision-making.

Working safely and ethically

Students should adhere to safe and ethical working practices, demonstrating academic integrity e.g. properly citing secondary sources, not falsifying data, and avoiding plagiarism. Due attention to environmental impact may be demonstrated in various ways including: avoidance of wastage; using safe waste disposal, and minimizing damage to local environments whilst undertaking an investigation.

PART 2—ECOSYSTEMS AND SOCIETIES

NATURE OF THE SUBJECT

The prime intent of this course is to provide students with a coherent perspective on the interrelationships between ecosystems and societies; one that enables them to adopt an informed personal response to the wide range of pressing environmental issues that they will inevitably come to face. Students' attention can be constantly drawn to their own relationship with their environment and the significance of choices and decisions they make in their own lives. It is intended that students develop a sound understanding of the interrelationships between ecosystems and societies, rather than a purely journalistic appreciation of environmental issues. The teaching approach therefore needs to be conducive to students evaluating the scientific, ethical and socio-political aspects of issues.

Systems Approach

The systems approach is central to the course and has been employed for a number of reasons. The very nature of environmental issues demands a holistic treatment. In reality, an ecosystem functions as a whole and the traditional reductionist approach of science inevitably tends to overlook or, at least, understate this important quality. Furthermore, the systems approach is common to many disciplines (eg economics, geography, politics, ecology). It emphasizes the similarities between the ways in which matter, energy and information flow (not only in biological systems but in, for example, transport and communication systems). This approach therefore integrates the perspectives of different disciplines. Given the integrated nature of this subject, stressing the links between areas of the syllabus is critical and should be considered when planning the delivery of the course.

Sustainability

The concept of sustainability is central to an understanding of the nature of interactions between ecosystems and societies. Resource management issues are essentially issues of sustainability and students' attention should be drawn to this throughout the course.

Holistic Evaluation

It is important that students develop a holistic appreciation of the complexities of environmental issues in which the interaction between ecosystems and societies is central. The course requires that students consider the costs and the benefits of human activities, both to the environment and to societies, over the short and long term. In doing so, students will arrive at informed personal viewpoints. They should be aware of and be able to justify their own position and to appreciate the views of others along the continuum of environmental philosophies. Their viewpoints may vary according to the issues being considered.

Local and Global Material

This course requires study of ecosystems and societies at a range of scales from local to global, but the teaching of this course should be firmly rooted in the local environment. There are many references throughout the syllabus to “local examples”, and fieldwork will inevitably be based on local ecosystems. A national or regional perspective is appropriate for the study of certain issues such as resource management and pollution management. Many environmental issues are international in nature such as climate change and management of the oceans. On a broader scale, the course naturally leads students to an appreciation of the nature and values of internationalism since the resolution of the major environmental issues rests heavily upon international relationships and agreements.

SYLLABUS OVERVIEW

A syllabus overview of the Diploma Programme ecosystems and societies pilot course is provided below.

Topics		Teaching hours
1	Systems and Models	5
2	The Ecosystem	31
3	Human Population, Carrying Capacity and Resource Use	39
4	Conservation and Biodiversity	15
5	Pollution Management	18
6	The Issue of Global Warming	6
7	Environmental Value Systems	6

SYLLABUS OUTLINE

		Teaching hours
Topic 1	Systems and Models	[5]
Topic 2	The Ecosystem	[31]
	2.1 Structure	4
	2.2 Measuring Abiotic Components of the System	1
	2.3 Measuring Biotic Components of the System	4
	2.4 Biomes	3
	2.5 Function	7
	2.6 Changes	7
	2.7 Measuring Changes in the System	5
Topic 3	Human Population, Carrying Capacity and Resource Use	[39]
	3.1 Population Dynamics	5
	3.2 Resources—Natural Capital	8
	3.3 Energy Resources	4
	3.4 The Soil System	4
	3.5 Food Resources	6
	3.6 Water Resources	3
	3.7 Limits to Growth	2.5
	3.8 Environmental Demands of Human Populations	6.5
Topic 4	Conservation and Biodiversity	[15]
	4.1 Biodiversity in Ecosystems	3
	4.2 Evaluating Biodiversity and Vulnerability	6
	4.3 Conservation of Biodiversity	6

Topic 5	Pollution Management	[18]
	5.1 Nature of Pollution	1
	5.2 Detection and Monitoring of Pollution	3
	5.3 Approaches to Pollution Management	2
	5.4 Eutrophication	3
	5.5 Solid Domestic Waste	2
	5.6 Depletion of Stratospheric Ozone	3
	5.7 Urban Air Pollution	2
	5.8 Acid Deposition	2
Topic 6	The Issue of Global Warming	[6]
Topic 7	Environmental Value Systems	[6]

SYLLABUS DETAILS

Topic 1 : Systems and Models (5h)

A.S.

Obj

This topic may best be viewed as a theme to be used in the delivery of other topics, rather than as an isolated teaching topic.

It is essential that the systems approach is used throughout this course. This approach identifies the elements of systems and examines the relationships and processes that link these elements into a functioning entity.

The systems approach also emphasizes the similarities between environmental systems, biological systems and artificial entities such as transport and communication systems. This approach stresses that there are concepts, techniques and terms that can be transferred from one discipline (such as ecology) to another (such as engineering).

This topic identifies some of the underlying principles that can be applied to living systems, from the level of the individual up to that of the whole biosphere. It would therefore be helpful to describe and analyse the systems addressed in the terms laid out in this topic (wherever possible).

- | | | |
|--------------|--|----------|
| 1.1.1 | Outline the concept and characteristics of systems. | 2 |
| | The emphasis will be on ecosystems but some mention should be made of economic, social and value systems. Cross reference 7.1.1. | |
| 1.1.2 | Apply the systems concept at a range of scales. | 2 |
| | The range must include a small-scale local ecosystem, a large ecosystem such as a biome, and Gaia as an example of a global system. | |
| 1.1.3 | Define the terms <i>open system</i> , <i>closed system</i> and <i>isolated system</i> . | 1 |
| | These terms should be applied when characterizing real systems. | |
| | <ul style="list-style-type: none">• An open system exchanges matter and energy with its surroundings (eg an ecosystem).• A closed system exchanges energy but not matter; the “Biosphere II” experiment was an attempt to model this. Strictly, closed systems do not occur naturally on Earth, but all the global cycles of matter, eg the water and nitrogen cycles, approximate to closed systems.• An isolated system exchanges neither matter nor energy. No such systems exist (with the possible exception of the entire cosmos). | |

A.S.		Obj
1.1.4	Describe how the first and second laws of thermodynamics are relevant to environmental systems. The first law concerns the conservation of energy. The second law explains the dissipation of energy that is then not available to do work, bringing about disorder. The second law is most simply stated as, “in any isolated system entropy tends to increase spontaneously”. This means that energy and materials go from a concentrated to a dispersed form (the availability of energy to do work diminishes) and the system becomes increasingly disordered. Both laws should be examined in relation to the energy transformations and maintenance of order in living systems. Cross reference 2.5.3.	2
1.1.5	Explain the nature of equilibria. A steady-state equilibrium should be understood as the common property of most open systems in nature. A static equilibrium, in which there is no change, should be appreciated as a condition to which natural systems can be compared. (Since there is disagreement in the literature regarding the definition of dynamic equilibrium, this term should be avoided.) Students should appreciate, however, that some systems may undergo long-term changes to their equilibrium while retaining an integrity to the system (eg succession). The relative stability of an equilibrium—the tendency of the system to return to that original equilibrium following disturbance, rather than adopting a new one—should also be understood.	3
1.1.6	Define and explain the principles of <i>positive feedback</i> and <i>negative feedback</i> . The self-regulation of natural systems is achieved by the attainment of equilibrium through feedback systems. Negative feedback is a self-regulating method of control leading to the maintenance of a steady-state equilibrium—it counteracts deviation, eg predator-prey relationships. Positive feedback leads to increasing change in a system—it accelerates deviation, eg the exponential phase of population growth. Feedback links involve time lags. Cross reference with 2.6.3 and 6.1.4.	1, 3
1.1.7	Describe transfer and transformation processes. Transfers normally flow through a system and involve a change in location. Transformations lead to an interaction within a system in the formation of a new end product, or involve a change of state. Using water as an example, run-off is a transfer process and evaporation is a transformation process. Dead organic matter entering a lake is an example of a transfer process; decomposition of this material is a transformation process. Cross reference with 2.5.3 and 2.5.4.	2
1.1.8	Distinguish between <i>flows</i> (inputs and outputs) and <i>storages</i> (stock) in relation to systems. Identify flows through systems and describe their direction and magnitude. Cross reference with 2.5.3 and 2.5.4.	2

A.S.		Obj
1.1.9	Construct and analyse quantitative models involving flows and storages in a system. Natural storages, yields and outputs should be included in the form of clearly constructed diagrammatic and graphical models. Cross reference with 2.5.3 and 2.5.4.	3
1.1.10	Evaluate the strengths and limitations of models. A model is a simplified description designed to show the structure or workings of an object, system or concept. In practice, some models require approximation techniques to be used. For example, predictive models of climate change may give very different results. In contrast, an aquarium may be a relatively simple ecosystem but demonstrates many ecological concepts. Cross reference Topic 6.	3

Topic 2: The Ecosystem

A.S.

Obj

The techniques required in this topic may be exemplified through practical work in marine, terrestrial, freshwater or urban ecosystems, or any combination of these. The selection of environments can be made according to the local systems available to the students, and the most convenient systems for demonstrating the techniques in question. However, there is an advantage in using the various practical measurements to quantify different aspects of the **same** ecosystem, where possible. In this way the techniques are not simply rehearsed in isolation, but can be used to build up a holistic model of that system.

2.1 Structure (4h)

- | | | |
|-------|--|------|
| 2.1.1 | Distinguish between <i>biotic</i> and <i>abiotic</i> (physical) components of an ecosystem. | 2 |
| 2.1.2 | Define the term <i>trophic level</i> . | 1 |
| 2.1.3 | Identify and explain trophic levels in food chains and food webs selected from the local environment.

Relevant terms (eg producers, consumers, decomposers, herbivores, carnivores, top carnivores) should be applied to local, named examples and other food chains and food webs. | 2, 3 |
| 2.1.4 | Explain the principles of pyramids of numbers and pyramids of biomass, and construct such pyramids from given data.

Pyramids are graphical models of the quantitative differences that exist between the trophic levels of a single ecosystem. A pyramid of biomass represents the standing stock of each trophic level measured in units such as grams of biomass per square metre (g m^{-2}). Biomass may also be measured in units of energy, such as J m^{-2} .

In accordance with the second law of thermodynamics, there is a tendency for numbers and quantities of biomass and energy to decrease along food chains, therefore the pyramids become narrower as one ascends. Pyramids of numbers can sometimes display different patterns, e.g. when individuals at lower trophic levels are relatively large. Similarly, pyramids of biomass can show greater quantities at higher trophic levels because they represent the biomass present at a given time (there may be marked seasonal variations). Both pyramids of numbers and pyramids of biomass represent storages. | 3 |

A.S.		Obj
2.1.5	Discuss how the pyramid structure affects the functioning of an ecosystem. This should include concentration of non-biodegradable toxins in food chains (cross reference with 5.3.3.), limited length of food chains, vulnerability of top carnivores. Definitions of the terms biomagnification, bioaccumulation and bioconcentration are not required.	3
2.1.6	Define the terms <i>species</i> , <i>population</i> , <i>habitat</i> , <i>niche</i> , <i>community</i> and <i>ecosystem</i> with reference to local examples.	1
2.1.7	Describe and explain population interactions using examples of named species. Include competition, parasitism, mutualism, predation and herbivory. Mutualism is an interaction in which both species derive benefit. Interactions should be understood in terms of the influences each species has on the population dynamics of others, and upon the carrying capacity of the others' environment. Graphical representations of these influences should be interpreted.	2, 3
 2.2 Measuring Abiotic Components of the System (1h) 		
2.2.1	List the significant abiotic (physical) factors of an ecosystem.	1
2.2.2	Describe and evaluate methods for measuring at least three abiotic factors within an ecosystem. Students should know methods for measuring any three significant abiotic factors and how these may vary in a given ecosystem with depth, time or distance. For example: <ul style="list-style-type: none"> • marine—salinity, pH, temperature, dissolved oxygen, wave action • freshwater—turbidity, flow velocity, pH, temperature, dissolved oxygen • terrestrial—temperature, light intensity, wind speed, particle size, slope, soil moisture, drainage, mineral content. This activity may be carried out effectively in conjunction with an examination of related biotic components.	2, 3

A.S.		Obj
2.3 Measuring Biotic Components of the System (4h)		
2.3.1	Construct simple keys and use published keys for the identification of organisms. Students could practise with keys supplied and then construct their own keys for up to eight species.	3
2.3.2	Describe and evaluate methods for estimating abundance of organisms. Methods should include capture-mark-release-recapture (Lincoln index) and quadrats for measuring population density, percentage frequency and percentage cover.	2, 3
2.3.3	Describe and evaluate methods for estimating the biomass of trophic levels in a community. Dry weight measurements of quantitative samples could be extrapolated to estimate total biomass.	2, 3
2.3.4	Define the term <i>diversity</i> . Diversity is often considered as a function of two components: the number of different species and the relative numbers of individuals of each species.	1
2.3.5	Apply Simpson's diversity index and outline its significance.	2

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

Students are not required to memorize this formula but must know the meaning of the symbols:

D = diversity index
 N = total number of organisms of all species found
 n = number of individuals of a particular species

D is a measure of species richness. A high value of D suggests a stable and ancient site and a low value of D could suggest pollution, recent colonization or agricultural management. The index is normally used in studies of vegetation but can also be applied to comparisons of animal (or even all species) diversity.

A.S.		Obj
	2.4 Biomes (3h)	
2.4.1	Define the term <i>biome</i> .	1
2.4.2	Explain the distribution, structure and relative productivity of tropical rainforests, deserts, tundra and any one other biome. Refer to prevailing climate and limiting factors. For example, tropical rainforests are found close to the equator where there is high insolation and rainfall and where light and temperature are not limiting. The other biome may be, for example, temperate grassland or a local example. Limit climate to temperature, precipitation and insolation.	3
	2.5 Function (7h)	
2.5.1	Explain the role of producers, consumers and decomposers in the ecosystem.	3
2.5.2	Describe photosynthesis and respiration in terms of inputs, outputs and energy transformations. Biochemical details are not required. Details of chloroplasts, light- dependent and light-independent reactions, mitochondria, carrier systems, ATP and specific intermediate biochemicals are not expected. Photosynthesis should be understood as requiring carbon dioxide, water, chlorophyll and certain visible wavelengths of light to produce organic matter and oxygen. The transformation of light energy into the chemical energy of organic matter should be appreciated. Respiration should be recognized as requiring organic matter and oxygen to produce carbon dioxide and water. Without oxygen, carbon dioxide and other waste products are formed. Energy is released in a form available for use by living organisms, but is ultimately lost as heat.	2

A.S.		Obj
2.5.3	<p>Describe and explain the transfer and transformation of energy as it flows through an ecosystem.</p> <p>Explain pathways of incoming solar radiation incident on the ecosystem including:</p> <ul style="list-style-type: none"> • loss of radiation through reflection and absorption • conversion of light to chemical energy • loss of chemical energy from one trophic level to another • efficiencies of transfer • overall conversion of light to heat energy by an ecosystem • re-radiation of heat energy to the atmosphere. <p>Construct and analyse simple energy-flow diagrams illustrating the movement of energy through ecosystems, including the productivity of the various trophic levels.</p> <p>The distinction between storages of energy illustrated by boxes in energy-flow diagrams (representing the various trophic levels), and the flows of energy or productivity often shown as arrows (sometimes of varying widths) needs to be emphasized. The former are measured as the amount of energy or biomass per unit area and the latter are given as rates, eg $\text{J m}^{-2} \text{day}^{-1}$.</p>	2, 3
2.5.4	<p>Describe and explain the transfer and transformation of materials as they cycle within an ecosystem.</p> <p>Processes involving the transfer and transformation of carbon, nitrogen and water as they cycle within an ecosystem should be described, and the conversion of organic and inorganic storage noted where appropriate. Construct and analyse flow diagrams of these cycles.</p>	2, 3
2.5.5	<p>Define the terms <i>gross productivity</i>, <i>net productivity</i>, <i>primary productivity</i> and <i>secondary productivity</i>.</p> <p>Productivity is production per unit time.</p>	1
2.5.6	<p>Define the terms and calculate the values of both <i>gross primary productivity</i> (GPP) and <i>net primary productivity</i> (NPP) from given data.</p> <p>Use the equation $\text{NPP} = \text{GPP} - \text{R}$</p>	1, 2
2.5.7	<p>Define the terms and calculate the values of both <i>gross secondary productivity</i> (GSP) and <i>net secondary productivity</i> (NSP) from given data.</p> <p>Use the equations</p> $\text{NSP} = \text{GSP} - \text{R}$ $\text{GSP} = \text{food eaten} - \text{fecal loss}$ <p>The term assimilation is sometimes used instead of secondary productivity.</p>	1, 2

A.S. Obj

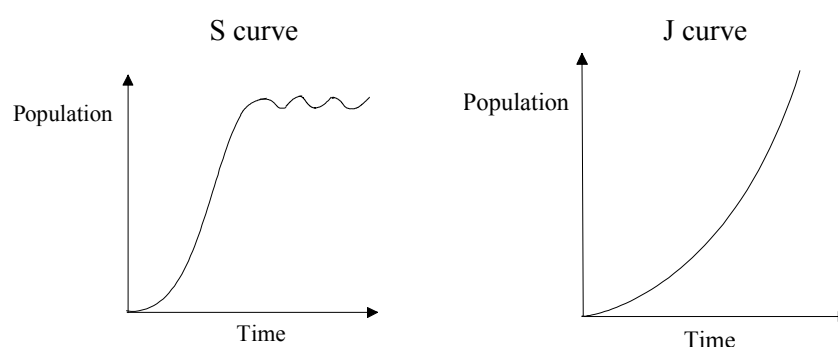
2.6 Changes (7h)

2.6.1 Explain the concepts of limiting factors and carrying capacity in the context of population growth. **3**

Cross reference 3.7.1

2.6.2 Describe and explain “S” and “J” population growth curves. **2, 3**

Explain changes in both numbers and rates of growth in standard S and J population growth curves. Population curves should be sketched, described, interpreted and constructed from given data. Cross reference 3.1.1.



2.6.3 Describe the role of density-dependent and density-independent factors, and internal and external factors, in the regulation of populations. **2**

According to theory, density-dependent factors operate as negative feedback mechanisms leading to stability or regulation of the population.

Both types of factors may operate on a population. Many species, particularly *r*-strategists, are probably regulated by density-independent factors, of which weather is the most important. Internal factors might include density-dependent fertility or size of breeding territory, and external factors might include predation or disease. Cross reference 3.7.1

2.6.4 Describe the principles associated with survivorship curves including, *K*- and *r*-strategists. **2**

K- and *r*-strategists represent idealized categories and many organisms occupy a place on the continuum.

Students should be familiar with interpreting features of survivorship curves including logarithmic scales.

2.6.5 Describe the concept and processes of succession in a named habitat. **2**

Study named examples of organisms from a pioneer community, seral stages and climax community.

The concept of succession, occurring over time, should be carefully distinguished from the concept of zonation which refers to a spatial pattern.

A.S.		Obj
2.6.6	<p>Explain the changes in energy flow, gross and net productivity, diversity and mineral cycling in different stages of succession.</p> <p>In early stages gross productivity is low due to the initial conditions and low density of producers. The proportion of energy lost through community respiration is relatively low too, so net productivity is high, i.e. the system is growing and biomass is accumulating. In later stages, with an increased consumer community, gross productivity may be high in a climax community. However, this is balanced by respiration, so net productivity approaches zero and the production:respiration (P:R) ratio approaches 1.</p>	3
2.6.7	<p>Describe factors affecting the nature of climax communities.</p> <p>Climatic and edaphic factors determine the nature of a climax community. Human factors frequently affect this process through, eg fire, agriculture, grazing, habitat destruction.</p>	2
2.7 Measuring Changes in the System (5h)		
2.7.1	<p>Describe and evaluate methods for measuring changes in abiotic and biotic components of an ecosystem along an environmental gradient.</p> <p>Cross reference with topics 2.2. and 2.3.</p>	2, 3
2.7.2	<p>Describe and evaluate methods for measuring changes in abiotic and biotic components of an ecosystem due to a specific human activity.</p> <p>Methods and changes should be selected appropriately for the human activity chosen. Suitable human impacts for study might include toxins from mining activity, landfills, eutrophication, effluent, oil spills and overexploitation. This could include repeated measurements on the ground, satellite images and maps. Cross reference with topics 2.2. and 2.3.</p>	2, 3
2.7.3	<p>Describe and evaluate the use of environmental impact assessments (EIAs).</p> <p>Students should have the opportunity to see an actual EIA study. They should realize that an EIA involves production of a baseline study before any environmental development, assessment of possible impacts, and monitoring of change during and after the development.</p>	2, 3

Topic 3: Human Population, Carrying Capacity and Resource Use

A.S.		Obj
	3.1 Population Dynamics (5h)	
3.1.1	Describe the nature and explain the implications of exponential growth in human populations.	2, 3
3.1.2	Calculate and explain, from given data, the values of crude birth rate, crude death rate, fertility, doubling time and natural increase rate.	2, 3
3.1.3	Analyse age/sex pyramids and diagrams showing demographic transition models.	3
3.1.4	Discuss the use of models in predicting the growth of human populations. This might include computer simulations, statistical/demographic tables for less economically developed countries (LEDCs) and more economically developed countries (MEDCs), age/sex pyramids and graphical extrapolation of population curves.	3
	3.2 Resources—Natural Capital (8h)	
3.2.1	Explain the concept of resources in terms of natural capital and natural income. Ecologically minded economists describe resources as “natural capital”. If properly managed, renewable and replenishable resources are forms of wealth that can produce “natural income” indefinitely in the form of valuable goods and services. This income may consist of marketable commodities such as timber and grain (goods) or may be in the form of ecological or life-support services such as the flood and erosion protection provided by forests (services). Similarly, non-renewable resources can be considered in parallel to those forms of economic capital that cannot generate wealth without liquidation of the estate.	3
3.2.2	Define the terms <i>renewable</i> , <i>replenishable</i> and <i>non-renewable natural capital</i> . There are three broad classes of natural capital. <ul style="list-style-type: none"> • Renewable natural capital, such as living species and ecosystems, is self-producing and self-maintaining and uses solar energy and photosynthesis. This natural capital can yield marketable goods such as wood fibre, but may also provide unaccounted essential services when left in place, eg climate regulation. • Replenishable natural capital, such as groundwater and the ozone layer, is non-living but is also often dependent on the solar “engine” for renewal. • Non-renewable (except on a geological timescale) forms of natural capital, such as fossil fuel and minerals, are analogous to inventories: any use implies liquidating part of the stock. 	1
3.2.3	Explain the dynamic nature of the concept of a resource. Consider how cultural, economic, technological and other factors influence the status of a resource over time and space. For example, uranium, due to the development of nuclear technology, has only recently become a valuable resource.	3

A.S.**Obj****3.2.4**

Discuss the view that the environment can have its own intrinsic value.

3

Organisms or ecosystems that are valued on aesthetic or intrinsic grounds may not provide commodities identifiable as either goods or services, and so remain unpriced or undervalued from an economic viewpoint. Organisms or ecosystems regarded as having intrinsic value, for instance from an ethical, spiritual or philosophical perspective, are valued regardless of their potential use to humans. Therefore diverse perspectives may underlie the evaluation of natural capital.

Attempts are being made to acknowledge diverse valuations of nature (eg biodiversity, rate of depletion of natural resources) so that they may be weighed more rigorously against more common economic values (eg gross national product (GNP)). However, some argue that these valuations are impossible to quantify and price realistically. Not surprisingly, much of the sustainability debate centres around the problem of how to weigh conflicting values in our treatment of natural capital.

3.2.5Explain the concept of *sustainability* in terms of natural capital and natural income.**3**

The term “sustainability” has been given a precise meaning in this syllabus. Students should understand that any society that supports itself in part by depleting essential forms of natural capital is unsustainable. If human well-being is dependent on the goods and services provided by certain forms of natural capital, then long-term harvest (or pollution) rates should not exceed rates of capital renewal. Sustainability means living, within the means of nature, on the “interest” or sustainable income generated by natural capital.

A.S. **Obj**
3.2.6 Discuss the concept of sustainable development. **3**

The term “sustainable development” was first used in 1987 in *Our Common Future* (The Brundtland Report) and was defined as development which meets current needs without compromising the ability of future generations to meet their own needs. The value of this approach is a matter of considerable debate and there is now no single definition for sustainable development. For example, some economists may view sustainable development as a stable annual return on investment regardless of the environmental impact whereas some environmentalists may view it as a stable return without environmental degradation.

The role of the Rio Earth Summit (1992) leading to Agenda 21 and the Johannesburg Earth Summit (2002) should be considered in the development of changing attitudes to sustainability and economic growth.

3.2.7 Calculate and explain sustainable yields from given data. **2, 3**

Sustainable yield (SY) may be calculated as the rate of increase in natural capital, i.e. that which can be exploited without depleting the original stock or its potential for replenishment. For example, the annual sustainable yield for a given crop may be estimated simply as the annual gain in biomass or energy through growth and recruitment. Thus,

$$SY = (\text{total biomass/energy at time } t+1) - (\text{total biomass/energy at time } t)$$

$$SY = (\text{annual growth and recruitment}) - (\text{annual death and emigration})$$

3.3 Energy Resources (4h)

3.3.1 Outline the range of energy sources available to society. **2**

3.3.2 Evaluate the advantages and disadvantages of two contrasting energy sources. **3**

Consider one non-renewable (fossil fuels or nuclear) and one renewable energy source.

3.3.3 Discuss the factors which affect the choice of energy sources adopted by different societies. **3**

This may include availability, economic, cultural, environmental and technological factors.

3.4 The Soil System (4h)

3.4.1 Outline how soil systems integrate aspects of living systems. **2**

Emphasize a systems approach. Students should draw diagrams that show links between the soil, lithosphere, atmosphere and living organisms. The soil as a living system should be considered with reference to a generalized soil profile. Studies of specific soil profiles, eg podsol, are not required.

Transfers of material (including deposition) result in reorganization of the soil. There are inputs of organic and parent material, precipitation, infiltration and energy. Outputs include leaching, uptake by plants and mass movement. Transformations include decomposition, weathering and nutrient cycling.

A.S.		Obj
3.4.2	Compare the structure and properties of sand, clay and loam soils, including their effect on primary productivity. Consider mineral content, drainage, water-holding capacity, air spaces, biota and potential to hold organic matter, and link these to primary productivity.	2
3.4.3	Outline the processes and consequences of soil degradation. Human activities such as overgrazing, deforestation, unsustainable agriculture and irrigation cause processes of degradation. These include soil erosion, toxification and salinization. Desertification (enlargement of deserts through human activities) can be associated with this degradation.	2
3.4.4	Outline soil conservation measures. Consider: <ul style="list-style-type: none">• soil conditioners (eg use of lime and organic materials)• wind reduction techniques (wind breaks, shelter belts, strip cultivation)• cultivation techniques (terracing, contour-plowing)• efforts to stop plowing of marginal lands.	2
3.4.5	Evaluate soil management strategies in a named commercial farming system and in a named subsistence farming system.	3

3.5 Food Resources (6h)

3.5.1	Outline the issues involved in the imbalance in global food supply. Students should appreciate the differences in food production and distribution around the world, including the socio-political, economic and ecological influences on these. Cross reference 3.7.1.	2
3.5.2	Compare the efficiency of terrestrial and aquatic food production systems. Compare these in terms of their trophic levels and efficiency of energy conversion. There is no need to consider individual production systems in detail. In terrestrial systems, most food is harvested from relatively low trophic levels (producers and herbivores). However, in aquatic systems, perhaps largely due to human tastes, most food is harvested from higher trophic levels where the total storages are much smaller. Although energy conversions along the food chain may be more efficient in aquatic systems, the initial fixing of available solar energy by primary producers tends to be less efficient due to the absorption and reflection of light by water.	2

A.S.		Obj
3.5.3	Compare the inputs and outputs of materials and energy (energy efficiency), the system characteristics and evaluate the relative environmental impacts for two named food production systems.	2, 3

The systems selected should both be terrestrial or both aquatic. In addition, the inputs and outputs of the two systems should differ qualitatively and quantitatively (not all systems will be different in all aspects). The pair of examples could be North American cereal farming and subsistence farming in some parts of South-east Asia, intensive beef production in the developed world and the Maasai tribal use of livestock, or commercial salmon farming in Norway/Scotland and rice-fish farming in Thailand. Other local or global examples are equally valid.

Factors to be considered should include:

- inputs—eg fertilizers (artificial and natural), irrigation water, pesticides, fossil fuels, food distribution, human labour, seed, breeding stock
- system characteristics—eg selective breeding, genetically engineered organisms, monoculture versus polyculture, sustainability
- socio-cultural—eg for the Maasai, cattle equals wealth and quantity is more important than quality
- environmental impact—eg pollution, habitat loss, reduction in biodiversity, soil erosion
- outputs—eg food quality and quantity, pollutants, soil erosion.

3.5.4.	Discuss the links that exist between social systems and food production systems.	3
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This could be illustrated through the use of examples, such as:

- The way in which the low population densities and belief systems of shifting cultivators links with the ecosystem of “slash and burn” agriculture.
- The relationship between high population densities, culture, soil fertility and the wet-rice ecosystem of South-east Asia.
- The link between the political economy of modern urban society, corporate capitalism and agro-ecosystems.

3.6 Water Resources (3h)

3.6.1	Describe the Earth’s water budget.	2
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Only a small fraction (2.6% by volume) of the Earth’s water supply is fresh water. Of this over 80% is in the form of ice caps and glaciers, 0.6% is groundwater and the rest is made up of lakes, soil water, atmospheric water vapour, rivers and biota in decreasing order of storage size. Precise figures are not required.

3.6.2	Describe and evaluate the sustainability of fresh water resource usage with reference to a case study.	2, 3
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Irrigation, industrialization and population increase all make demands on the supplies of fresh water. Global warming may disrupt rainfall patterns and water supplies. The hydrological cycle supplies humans with fresh water but we are withdrawing water from underground aquifers and degrading it with wastes at a greater rate than it can be replenished. Consider the increased demand for fresh water, inequity of usage and political consequences, methods of reducing use and increasing supplies. A case study must be explored which covers some of these issues and demonstrates either sustainable or unsustainable water use.

A.S.

Obj

3.7 Limits to Growth (2.5h)

- 3.7.1** Explain the difficulties in applying the concept of *carrying capacity* to local human populations. **3**

By examining carefully the requirements of a given species and the resources available, it might be possible to estimate the carrying capacity of that environment for the species. This is problematic in the case of human populations for a number of reasons. The range of resources used by humans is usually much greater than for any other species. Furthermore, when one resource becomes limiting, humans show great ingenuity in substituting one resource for another. Resource requirements vary according to lifestyles, which differ from time to time and from population to population. Technological developments give rise to continual changes in the resources required and available for consumption. Human populations also regularly import resources from outside their immediate environment which enables them to grow beyond the boundaries set by their local resources and increases their carrying capacity. While importing resources in this way increases the carrying capacity for the local population, it has no influence on global carrying capacity. All these variables make it practically impossible to make reliable estimates of carrying capacities for human populations.

- 3.7.2** Explain how absolute reductions in energy and material use, reuse and recycling can affect human carrying capacity. **3**

Human carrying capacity is determined by the rate of energy and material consumption, the level of pollution and the extent of human interference in global life support systems. While reuse and recycling reduce these impacts, they can also increase human carrying capacity.

3.8 Environmental Demands of Human Populations (6.5h)

- 3.8.1** Explain the concept of an *ecological footprint* as a model for assessing the demands human populations make on their environment. **3**

The ecological footprint of a population is the area of land, in the same vicinity as the population, that would be required to provide all the population's resources and assimilate all its wastes. As a model, it is able to provide a quantitative estimate of human carrying capacity. It is, in fact, the inverse of carrying capacity. It refers to the area required to sustainably support a given population rather than the population that a given area can sustainably support.

- 3.8.2** Calculate from appropriate data the ecological footprint of a given population, stating the approximations and assumptions involved. **2**

Although the accurate calculation of an ecological footprint might be very complex, an approximation can be achieved through the following steps.

$$\text{Per capita land requirement for food production (ha)} = \frac{\text{Per capita food consumption (kg yr}^{-1}\text{)}}{\text{Mean food production per hectare of local arable land (kg ha}^{-1}\text{ yr}^{-1}\text{)}}$$

$$\text{Per capita land requirement for absorbing waste CO}_2\text{ from fossil fuels (ha)} = \frac{\text{Per capita CO}_2\text{ emission (kg C yr}^{-1}\text{)}}{\text{Net carbon fixation per hectare of local natural vegetation (kg C ha}^{-1}\text{ yr}^{-1}\text{)}}$$

The total land requirement (ecological footprint) can then be calculated as the sum of these two *per capita* requirements, multiplied by the total population.

This calculation clearly ignores the land or water required to provide any aquatic and atmospheric resources, assimilate wastes other than CO₂, produce the energy and material subsidies imported to the arable land for increasing yields, replace loss of productive land through urbanization, etc.

- 3.8.3** Describe and explain the differences between the ecological footprints of two human populations; one from an LEDC and one from an MEDC. **2, 3**

Data for food consumption are often given in grain equivalents, so that a population with a meat-rich diet would tend to consume a higher grain equivalent than a population that feeds directly on grain. Students should be aware that in MEDCs about twice as much energy in the diet is provided by animal products than in LEDCs. Grain production will be higher with intensive farming strategies. Populations more dependent on fossil fuels will have higher CO₂ emissions. Fixation of CO₂ is clearly dependent on climatic region and vegetation type. These, and other factors, will often explain the differences in the ecological footprints of populations in LEDCs and MEDCs.

A.S.

Obj

- 3.8.4** Discuss how national and international development policies and cultural influences can affect human population dynamics and growth. **3**

Many policy factors influence human population growth. Domestic and international development policies (which target the death rate through agricultural development, improved public health and sanitation, and better service infrastructure) may stimulate rapid population growth by lowering mortality without significantly affecting fertility. Some analysts believe that birth rates will come down by themselves as economic welfare improves and that the population problem is therefore better solved through policies to stimulate economic growth. Education about birth control encourages family planning. Parents may be dependent on their children for support in their later years and this may create an incentive to have many children. Urbanization may also be a factor in reducing crude birth rates. Policies directed toward the education of women, enabling women to have greater personal and economic independence, may be the most effective method for reducing population pressure.

- 3.8.5** Describe and explain the relationship between population, resource consumption and technological development, and their influence on carrying capacity and material economic growth. **2, 3**

Because technology plays such a large role in human life, many economists argue that human carrying capacity can be expanded continuously through technological innovation. For example, if we learn to use energy and material twice as efficiently, we can double the population or the use of energy without necessarily increasing the impact (load) imposed on the environment. However, to compensate for foreseeable population growth and the economic growth that is deemed necessary, especially in developing countries, it is suggested that efficiency would have to be raised by a factor of 4 to 10 to remain within global carrying capacity.

Topic 4: Conservation and Biodiversity

A.S.	Obj
4.1 Biodiversity in Ecosystems (3h)	
4.1.1 Define the terms <i>biodiversity</i> , <i>genetic diversity</i> , <i>species diversity</i> and <i>habitat diversity</i> .	1
4.1.2 Outline the mechanism of natural selection as a possible driving force for speciation. Speciation occurs as a result of the isolation (geographical or reproductive) of populations. The concept of fitness should be understood. The history of the development of the modern theory of evolution is not expected, neither is a detailed knowledge of genetics (including allele frequency).	2
4.1.3 State that isolation can lead to different species being produced that are unable to interbreed to yield fertile offspring. Isolation of populations, behavioural differences that preclude reproduction and the inability to produce fertile offspring (leading to speciation) should all be examined, with examples.	1
4.1.4 Explain how plate activity has influenced evolution and biodiversity. The consequences of plate tectonics on speciation should be understood (i.e. the separation of gene pools, formation of physical barriers and land bridges) together with the implications these consequences have for evolution. The role of plate activity in generating new and diverse habitats, thus promoting biodiversity should also be considered. Detailed understanding of the mechanism of plate tectonics is not required.	3
4.1.5 Explain the relationships among ecosystem stability, diversity, succession and habitat. Consider how: <ul style="list-style-type: none"> • diversity changes through succession • greater habitat diversity leads to greater species and genetic diversity • a complex ecosystem, with its variety of nutrient and energy pathways, provides stability • human activities modify succession, eg logging, grazing, burning • human activities often simplify ecosystems, rendering them unstable, eg North America wheat farming versus tall grass prairie. • an ecosystem's capacity to survive change may depend on diversity, resilience and inertia. 	3

A.S.

Obj

4.2 Evaluating Biodiversity and Vulnerability (6h)

- 4.2.1** Identify factors that lead to loss of diversity. **2**
- These include:
- natural hazard events (eg volcanoes, drought, ice age, meteor impact)
 - habitat degradation, fragmentation and loss
 - agricultural practices (eg monoculture, use of pesticides, use of genetically modified species)
 - introduction and/or escape of non-native species
 - pollution
 - hunting, collecting and harvesting.
- 4.2.2** Describe the vulnerability of tropical rainforests and their relative value in contributing to global biodiversity. **2**
- 4.2.3** Discuss current estimates of numbers of species and past and present rates of species extinction. **3**
- Examine the fossil record for evidence of mass extinctions in the past, and compare the possible causes of these to present day extinctions. The time frame of these periods of extinction should be considered.
- 4.2.4** Describe and explain the factors that may make species more or less prone to extinction. **2, 3**
- The following factors (among others) will affect the risk of extinction: numbers, degree of specialization, distribution, reproductive potential and behaviour, and trophic level.
- 4.2.5** Outline the factors used to determine a species' Red List conservation status. **1, 3**
- Students should be aware of the factors used to determine a species' conservation status and that a sliding scale operates. Students should appreciate that a range of factors are used to determine conservation status such as:
- population size
 - reduction in population size
 - numbers of mature individuals
 - geographic range and degree of fragmentation
 - quality of habitat
 - area of occupancy
 - probability of extinction.
- Definitions of the conservation status categories are not required and the term "criteria" has been avoided due to the complexity of the Red List classification system.

A.S.		Obj
4.2.6	Describe the case histories of three different species: one that has become extinct, another that is critically endangered, and a third species whose conservation status has been improved by intervention. Students should know the ecological, socio-political and economic pressures that caused or are causing the chosen species' extinction. The species' ecological roles and the possible consequences of their disappearance should be understood.	2
4.2.7	Describe the case history of a natural area of biological significance that is threatened by human activities. Students should know the ecological, socio-political and economic pressures that caused or are causing the degradation of the chosen area, and the consequent threat to biodiversity.	2
4.3 Conservation of Biodiversity (6h)		
4.3.1	State the arguments for preserving species and habitats. Students should appreciate arguments based on ethical, aesthetic, genetic resource and commercial (including opportunity cost) considerations. They should also appreciate life support/ecosystem support functions.	1
4.3.2	Compare the role and activities of governmental and non-governmental organizations in preserving and restoring ecosystems and biodiversity. Consider the United Nations Environment Programme (UNEP) as a governmental organization and the Worldwide Fund for Nature (WWF) and Greenpeace as non-governmental organizations. Compare UNEP and WWF in terms of use of the media, speed of response, diplomatic constraints and political influence. Consider also recent international conventions on biodiversity (eg Rio Earth Summit, 1992, and subsequent updates).	2
4.3.3	Outline the World Conservation Strategy. This is proposed by the International Union for the Conservation of Nature (IUCN), UNEP and WWF.	2
4.3.4	State and explain the criteria used to design reserves. In effect, protected areas may become “islands” within a country and will normally lose some of their diversity. The principles of island biogeography might be applied to the design of reserves. Appropriate criteria are discussed in the World Conservation Strategy.	1, 3
4.3.5	Evaluate the success of a named protected area. The granting of protected status to a species or ecosystem is no guarantee of protection without community support, adequate funding and proper research. Consider a specific local example.	3

A.S.

4.3.6

Discuss and evaluate the strengths and weaknesses of the species-based approach to conservation.

Obj

3

Students should consider the relative strengths and weaknesses of:

- The Convention on International Trade in Endangered Species (CITES)
- captive breeding and reintroduction programmes, and zoos
- aesthetic versus ecological value.

Topic 5: Pollution Management

A.S.

Obj

The purpose of this topic is to give a broad overview of pollution and its management with reference to examples from aquatic, terrestrial and atmospheric systems.

5.1 Nature of Pollution (1h)

5.1.1 Define the term *pollution*. 1

5.1.2 Distinguish between the terms *point source pollution* and *non-point source pollution* and outline the challenges they present for management. 2

Point source pollution is generally more easily managed because its impact is more localized making it easier to control emission, attribute responsibility and take legal action.

5.1.3 State the major sources of pollutants. 1

Sources of pollutants are combustion of fossil fuels, domestic waste, industrial waste, manufacturing and agricultural systems.

5.2 Detection and Monitoring of Pollution (3h)

5.2.1 Describe two direct methods of monitoring pollution. 2

Students should describe one method for air and one for soil or water.

5.2.2 Define the term *biochemical oxygen demand* (BOD) and explain how this indirect method is used to assess pollution levels in water. 1, 3

5.2.3 Describe and explain an indirect method of measuring pollution levels using a biotic index. 2, 3

This will involve levels of tolerance, diversity and abundance of organisms. The concept of indicator species should be understood. A polluted and an unpolluted site (eg upstream and downstream of a point source) should be compared.

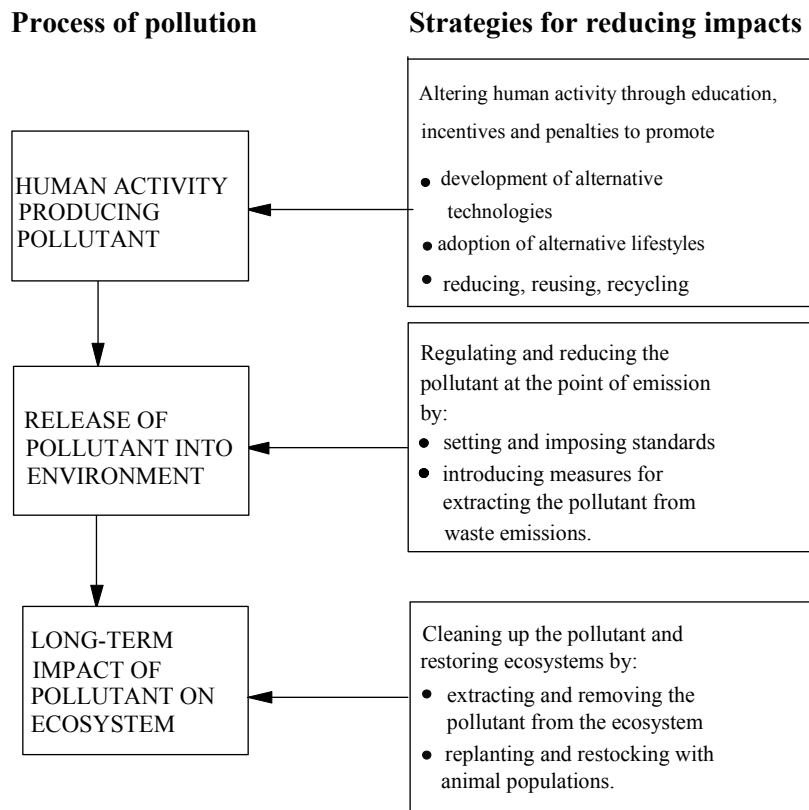
A.S.

Obj

5.3 Approaches to Pollution Management (2h)

5.3.1 Outline approaches to pollution management with respect to the following model.

2



Pollutants are produced through human activities and create long-term effects when released into ecosystems. Strategies for reducing these impacts can be directed at three different levels in the process: altering the human activity, regulating and reducing quantities of pollutant released at the point of emission, and cleaning up the pollutant and restoring ecosystems after pollution has occurred.

Using the model above, students should be able to show the value and limitations of each of the three different levels of intervention. In addition, students should appreciate the advantages of employing the earlier strategies over the later ones and the importance of collaboration in the effective management of pollution.

A.S.		Obj
5.3.2	Discuss the human factors that affect the approaches to pollution management. Cultural values, political systems and economic systems will influence the choice of pollution management strategies and their effective implementation. (Cross reference with Topic 7.) Real examples should be considered.	3
5.3.3	Evaluate the costs and benefits to society of the World Health Organization's ban on the use of the pesticide DDT.	3

5.4 Eutrophication (3h)

5.4.1	Outline the processes of eutrophication. Include increase in nitrates and phosphates leading to rapid growth of algae, accumulation of dead organic matter, high rate of decomposition and lack of oxygen. The role of positive feedback should be noted in these processes.	2
5.4.2	Evaluate the impacts of eutrophication. Include death of aerobic organisms, increased turbidity, loss of macrophytes, reduction in length of food chains and loss of species diversity.	3
5.4.3	Describe and evaluate pollution management strategies with respect to eutrophication. Students should apply the model in 5.3.1 in the evaluation of the strategies. For example: <ul style="list-style-type: none"> • “Altering the human activity producing pollution” can be exemplified by alternative methods of enhancing crop growth, alternative detergents, etc. • “Regulating and reducing pollutants at the point of emission” can be illustrated by sewage treatment processes that remove nitrates and phosphates from the waste. • “Clean up and restoration” can be exemplified by pumping mud from eutrophic lakes and reintroducing plant and fish species. 	2, 3

A.S.	Obj
5.5 Solid domestic waste (2h)	
5.5.1 Outline the types of solid domestic waste.	2
Students should consider their own and their community's generation of waste. Consider the different types of material, eg paper, glass, metal, plastics, organic waste (kitchen or garden), packaging, as well as their total volume.	
5.5.2 Describe and evaluate pollution management strategies for solid domestic (municipal) waste.	2, 3
Consider recycling, incineration, composting and landfill.	
5.6 Depletion of Stratospheric Ozone (3h)	
5.6.1 Outline the overall structure and composition of the atmosphere.	2
5.6.2 Describe the role of ozone in the absorption of ultraviolet radiation.	2
Ultraviolet radiation is absorbed during the formation and destruction of ozone from oxygen. Memorization of chemical equations is not required.	
5.6.3 Explain the interaction between ozone and halogenated organic gases.	3
Halogenated organic gases are very stable under normal conditions but can liberate halogen atoms when exposed to ultraviolet radiation in the stratosphere. These atoms react with monatomic oxygen and slow the rate of ozone reformation. Pollutants enhance the destruction of ozone thereby disturbing the equilibrium of the ozone production system (see 1.1.5).	
5.6.4 State the effects of ultraviolet radiation on living tissues and biological productivity.	1
The effects include mutation and subsequent effects on health and damage to photosynthetic organisms, especially phytoplankton and their consumers such as zooplankton.	
5.6.5 Describe three methods of reducing the manufacture and release of ozone-depleting substances.	2
For example, recycling refrigerants, alternatives to gas-blown plastics, alternative propellants and alternatives to methyl bromide.	
5.6.6 Describe and evaluate the role of national and international organizations in reducing the emissions of ozone-depleting substances.	2, 3
Examine the role of the United Nations Environmental Program (UNEP) in forging international agreements (eg Montreal Protocol and subsequent updates) on the use of ozone-depleting substances, and study the relative effectiveness of these agreements and the difficulties in implementing and enforcing them. In addition, students should be familiar with what steps national governments are taking to comply with these agreements.	

A.S.

Obj

5.7 Urban Air Pollution (2h)

5.7.1 State the source and outline the effect of tropospheric ozone. **1, 2**

When fossil fuels are burned, two of the pollutants emitted are hydrocarbons (from unburned fuel) and nitrogen oxide (NO). Nitrogen oxide reacts with oxygen to form nitrogen dioxide (NO₂), a brown gas which contributes to urban haze. Nitrogen dioxide can also absorb sunlight and break up to release oxygen atoms that combine with oxygen in the air to form ozone.

Ozone is a toxic gas and an oxidizing agent. It damages crops and forests, irritates eyes, can cause breathing difficulties in humans and may increase susceptibility to infection. It is highly reactive and can attack fabrics and rubber materials.

5.7.2 Outline the formation of photochemical smog. **2**

Photochemical smog is a mixture of about one hundred primary and secondary pollutants formed under the influence of sunlight. Ozone is the main pollutant.

The frequency and severity of photochemical smogs in an area depends on local topography, climate, population density and fossil fuel use. Precipitation cleans the air and winds disperse the smog. Thermal inversions trap the smogs in valleys (eg Los Angeles, Santiago, Mexico City, Rio de Janeiro, São Paulo, Beijing) and concentrations of air pollutants can build to harmful and even lethal levels.

5.7.3 Describe and evaluate pollution management strategies for urban air pollution. **2, 3**

Measures to reduce fossil fuel combustion should be considered, eg reducing demand for electricity and private cars and switching to renewable energy. Refer to clean-up measures eg catalytic converters.

5.8 Acid Deposition (2h)

5.8.1 Outline the chemistry leading to the formation of acidified precipitations. **2**

Refer to the conversion of sulfur dioxide and oxides of nitrogen (NO_x) into the sulfates and nitrates of dry deposition and the sulfuric and nitric acids of wet deposition. Knowledge of chemical equations is not required.

5.8.2 Describe three possible effects of acid deposition on soil, water and living organisms. **2**

Include:

- one direct effect, eg acid on aquatic organisms and coniferous forests
- one toxic effect, eg aluminium ions on fish
- one nutrient effect, eg leaching of calcium.

A.S.		Obj
5.8.3	Explain why the effect of acid deposition is regional rather than global. Refer to areas downwind of major industrial regions which are adversely affected by acid rain and link them to sources of sulfur dioxide and nitrogen dioxide emissions. Consider the effect of geology (rocks and soils) on water acidity through buffering.	3
5.8.4	Describe and evaluate pollution management strategies for acid deposition. Measures to reduce fossil fuel combustion should be considered, eg reducing demand for electricity and private cars and switching to renewable energy. Refer to clean-up measures at “end of pipe” locations (points of emission). Consider the role of international agreements in effecting change. The cost-effectiveness of spreading ground limestone in Swedish lakes in the early 1980s provides a good case study.	2, 3

Topic 6: The Issue of Global Warming (6h)

A.S.		Obj
	This topic allows the study of a controversial global issue in more depth. Expert opinion is divided on this issue and students should be encouraged to develop a personal viewpoint having considered the arguments. Cross reference Topic 7.	
6.1.1	Describe the role of greenhouse gases in maintaining mean global temperature. The greenhouse effect is a normal and necessary condition for life on Earth. Consider carbon dioxide (CO ₂) levels in geological times.	2
6.1.2	Describe how human activities add to greenhouse gases. Water, CO ₂ , methane and CFCs are the main greenhouse gases. Human activities are increasing levels of CO ₂ , methane and CFCs in the atmosphere which may lead to global warming.	2
6.1.3	Discuss qualitatively the potential effects of increased mean global temperature. Consider the potential effects on the distribution of biomes, global agriculture and human societies. Students should appreciate that effects might be adverse or beneficial, eg: <ul style="list-style-type: none"> • biomes shifting • change in location of crop growing areas • changed weather patterns • coastal inundation (due to thermal expansion of the oceans and melting of the polar ice caps) • human health (spread of tropical diseases). 	3
6.1.4	Discuss the feedback mechanisms that would be associated with an increase in mean global temperature. Any feedback mechanisms associated with global warming may involve very long time lags, eg: <ul style="list-style-type: none"> • negative feedback—increased evaporation in tropical latitudes leading to increased snowfall on the polar ice caps, which reduces the mean global temperature • positive feedback—increased thawing of permafrost leading to an increase in methane levels, which increases the mean global temperature. 	3

A.S.		Obj
6.1.5	Describe and evaluate pollution management strategies to address the issue of global warming. Students should consider the following strategies: <ul style="list-style-type: none">• global—intergovernmental and international agreements (eg Kyoto agreement and subsequent updates), carbon tax and carbon trading, alternative energy sources• local—allow students to explore their own lifestyle in the context of local greenhouse gas emissions• preventive and reactive Students should evaluate these strategies with regard to their effectiveness and the implications for MEDCs and LEDCs of reducing CO ₂ emissions in terms of economic growth and national development.	2, 3
6.1.6	Outline the arguments that are surrounding global warming. Students should appreciate the variety of sometimes conflicting arguments surrounding this issue. Note the complexity of the problem and the uncertainty of global climate models. Students should be aware of the concept of global dimming due to increased levels of atmospheric pollution.	2
6.1.7	Evaluate contrasting human perceptions of the issue of global warming. Students should explore different viewpoints in relation to their own.	3

Topic 7: Environmental Value Systems (6h)

A.S.

Obj

Understanding environmental value systems is a central theme in this course. Therefore, this topic should be used in the analysis of environmental issues throughout the course, as well as being taught as a discrete unit.

7.1.1

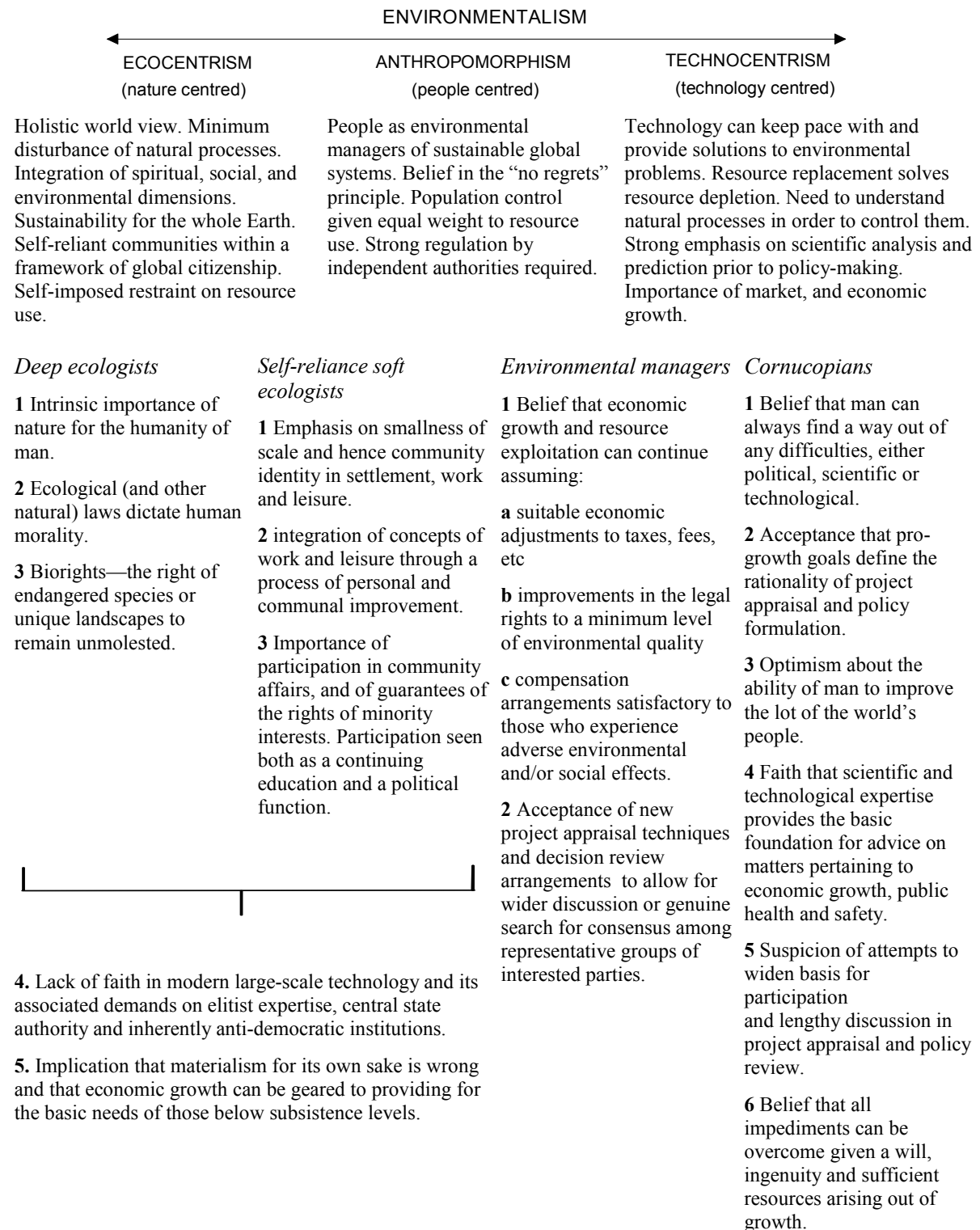
State what is meant by an environmental value system.

1

A particular world view or set of paradigms which shapes the way an individual or group of people perceive and evaluate environmental issues. This will be influenced by their cultural (including religious), economic and socio-political context.

An environmental value system is a system in the sense that it has inputs (eg education, cultural influences, religious doctrine, media, etc) and outputs (eg decisions, perspectives, courses of action) determined by processing these inputs.

7.1.2 Outline the range of environmental philosophies with reference to the model below. **2**



A.S.		Obj
7.1.3	Discuss how these philosophies influence the decision-making process with respect to environmental issues covered in this course.	3
7.1.4	Outline key historical influences on the development of the modern environmental movement. Consider major landmarks eg Minamata, Rachel Carson's <i>Silent Spring</i> , Bhopal, whaling (Save the Whale), Chernobyl, leading to environmental pressure groups, both local and global, the concept of stewardship and increased media coverage raising public awareness.	2
7.1.5	Compare the environmental value systems of two named societies. The societies chosen should demonstrate significant differences. For example <ul style="list-style-type: none">• First Nation Americans and European pioneers operating frontier economics, which involved exploitation of seemingly unlimited resources• Buddhist and Judaeo-Christian societies• Communist and Capitalist societies	2
7.1.6	Justify your personal viewpoint on environmental issues. Students should be encouraged to reflect upon where they stand on the continuum of environmental philosophies with regard to specific issues arising throughout the syllabus eg population control, resource exploitation, sustainable development, etc.	3

GLOSSARY

The purpose of the glossary is to ensure general agreement between teachers, students and examiners. It is not intended that students learn and recall the exact wording of these definitions, but they should be familiar with their meanings.

abiotic factor	A non-living, physical factor that may influence an organism or ecosystem, e.g. temperature, sunlight, pH, salinity, precipitation.
biochemical oxygen demand (BOD)	A measure of the amount of dissolved oxygen required to break down the organic material in a given volume of water through aerobic biological activity.
biodegradable	Capable of being broken down by natural biological processes, e.g. the activities of decomposer organisms.
biodiversity	The amount of biological or living diversity per unit area. It includes the concepts of species diversity, habitat diversity and genetic diversity.
biomass	The mass of organic material in organisms or ecosystems, usually per unit area. Sometimes the term “dry weight biomass” is used where mass is measured after the removal of water. Water is not organic material and inorganic material is usually relatively insignificant in terms of mass.
biome	A collection of ecosystems sharing similar climatic conditions, e.g. tundra, tropical rainforest, desert.
biosphere	That part of the Earth inhabited by organisms, i.e. the narrow zone (a few kilometres in thickness) in which plants and animals exist. It extends from the upper part of the atmosphere (where birds, insects and wind-blown pollen may be found) down to the deepest part of the Earth’s crust to which living organisms venture.
biotic factor	A living, biological factor that may influence an organism or ecosystem, e.g. predation, parasitism, disease, competition.
carrying capacity	The maximum number of a species or “load” that can be sustainably supported by a given environment.
climax community	A community of organisms that is more or less stable, and that is in equilibrium with natural environmental conditions such as climate; the end-point of ecological succession.
community	A group of populations living and interacting with each other in a common habitat.

competition	A common demand by two or more organisms upon a limited supply of a resource (e.g. food, water, light, space, mates, nesting sites). It may be intraspecific or interspecific.
correlation	A measure of the association between two variables. If two variables tend to move up or down together, they are said to be positively correlated. If they tend to move in opposite directions, they are said to be negatively correlated.
crude birth rate	The number of births per thousand individuals in a population per year.
crude death rate	The number of deaths per thousand individuals in a population per year.
demographic transition	A general model describing the changing levels of fertility and mortality in a human population over time. It was developed with reference to the transition experienced as developed countries (e.g. those of North America, Europe, Australasia) passed through the processes of industrialization and urbanization.
diversity	A generic term for heterogeneity. The scientific meaning of diversity becomes clear from the context in which it is used; it may refer to heterogeneity of species or habitat, or to genetic heterogeneity.
diversity, genetic	The range of genetic material present in a gene pool or population of a species.
diversity, habitat	The range of different habitats or number of ecological niches per unit area in an ecosystem, community or biome. Conservation of habitat diversity usually leads to the conservation of species and genetic diversity.
diversity index	A numerical measure of species diversity that is derived from both the number of species (variety) and their proportional abundance.
diversity, species	The variety of species per unit area. This includes both the number of species present and their relative abundance.
doubling time	The number of years it would take a population to double its size at its current growth rate. A natural increase rate of 1% will enable a human population to double in 70 years. Other doubling times can then be calculated proportionately, i.e. the doubling time for any human population is equal to 70 divided by the natural increase rate.
ecological footprint	The area of land and water required to support a defined human population at a given standard of living. The measure takes account of the area required to provide all the resources needed by the population, and the assimilation of all wastes. (A method of calculation is provided in 3.8.2).
ecosystem	A community of interdependent organisms and the physical environment they inhabit.
entropy	A measure of the amount of disorder, chaos or randomness in a system; the greater the disorder, the higher the level of entropy.

environmental impact assessment (EIA)	A method of detailed survey required, in many countries, before a major development. Ideally it should be independent of, but paid for by, the developer. Such a survey should include a baseline study to measure environmental conditions before development commences, and to identify areas and species of conservation importance. The report produced is known as an environmental impact statement (EIS) or environmental management review in some countries. The monitoring should continue for some time after the development.
equilibrium	A state of balance among the components of a system.
eutrophication	The natural or artificial enrichment of a body of water, particularly with respect to nitrates and phosphates, that results in depletion of the oxygen content of the water. Eutrophication is accelerated by human activities that add detergents, sewage or agricultural fertilizers to bodies of water.
evolution	The cumulative, gradual change in the genetic characteristics of successive generations of a species or race of an organism, ultimately giving rise to species or races different from the common ancestor. Evolution reflects changes in the genetic composition of a population over time.
feedback	The return of part of the output from a system as input, so as to affect succeeding outputs.
feedback, negative	Feedback that tends to damp down, neutralize or counteract any deviation from an equilibrium, and promotes stability.
feedback, positive	Feedback that amplifies or increases change; it leads to exponential deviation away from an equilibrium.
fertility	In the context of human populations this refers to the potential for reproduction exhibited in a population. It may be measured as fertility rate, which is the number of births per thousand women of child-bearing age. Alternatively it may be measured as total fertility, which is simply the average number of children a woman has in her lifetime.
Gaia	The Gaia hypothesis (developed by James Lovelock and named after an ancient Greek Earth goddess) compares the Earth to a living organism in which feedback mechanisms maintain equilibrium.
global warming	An increase in average temperature of the Earth's atmosphere.
GNP	Gross national product, the current value of all goods and services produced in a country per year.
greenhouse gases	Those atmospheric gases which absorb infrared radiation, causing world temperatures to be warmer than they would otherwise be. This process is sometimes known as "radiation trapping". The natural greenhouse effect is caused mainly by water and carbon dioxide. Human activities have led to an increase in the levels of carbon dioxide, methane and nitrous oxide in the atmosphere and there are fears that this may lead to global warming .

habitat	The environment in which a species normally lives.
halogenated organic gases	Usually known as halocarbons and first identified as depleting the ozone layer in the stratosphere. Now known to be potent greenhouse gases. The most well known are CFCs.
isolation	The process by which two populations become separated by geographical, behavioural, genetic or reproductive factors. If gene-flow between the two sub-populations is prevented, new species may evolve. See evolution .
K-strategists	Species using <i>K</i> -strategies will usually concentrate their reproductive investment in a small number of offspring thus increasing their survival rate and adapting them for living in long-term climax communities.
latitude	The angular distance from the equator (i.e. north or south of it) as measured from the centre of the Earth (usually in degrees).
LEDC	Less economically developed country: a country with low to moderate industrialization and low to moderate average GNP <i>per capita</i> .
MEDC	More economically developed country: a highly industrialized country with high average GNP <i>per capita</i> .
model	A simplified description designed to show the structure or workings of an object, system or concept.
mutualism	A relationship between individuals of two or more species in which all benefit and none suffer. (The term symbiosis will not be used.)
natural capital	A term sometimes used by economists for natural resources that, if appropriately managed, can produce a “natural income” of goods and services. The natural capital of a forest might provide a continuing natural income of timber, game, water and recreation.
natural capital, non-renewable	Natural resources which cannot be replenished within a timescale of the same order as that at which they are taken from the environment and used, e.g. fossil fuels.
natural capital, renewable	Natural resources that have a sustainable yield or harvest equal to or less than their natural productivity, e.g. food crops, timber.
natural capital, replenishable	Non-living natural resources that depend on the energy of the sun for their replenishment, e.g. groundwater.
natural increase, rate of	The form in which human population growth rates are usually expressed. $\frac{\text{Crude birth rate} - \text{crude death rate}}{10}$
niche	Inward and outward migration is ignored. A species’ share of a habitat and the resources in it. An organism’s ecological niche depends not only on where it lives but on what it does.

parasitism	A relationship between two species in which one species (the parasite) lives in or on another (the host), gaining all or much (in the case of a partial parasite) of its food from it.
plate tectonics	The movement of the eight major and several minor internally rigid plates of the lithosphere in relation to each other and to the partially mobile asthenosphere below.
pollution	The addition to an environment of a substance or an agent (such as heat) by human activity, at a rate greater than that at which it can be rendered harmless by the environment, and which has an appreciable effect on the organisms within it.
pollution, non-point source	The release of pollutants from numerous, widely dispersed origins, e.g. gases from the exhaust systems of vehicles.
pollution, point source	The release of pollutants from a single, clearly identifiable site, e.g. a factory chimney or the waste disposal pipe of a factory into a river.
population	A group of organisms of the same species living in the same area at the same time, and which are capable of interbreeding.
productivity, gross (GP)	The total gain in energy or biomass per unit area per unit time, which could be through photosynthesis in primary producers or absorption in consumers.
productivity, gross primary (GPP)	The total gain in energy or biomass per unit area per unit time fixed by photosynthesis in green plants.
productivity, net (NP)	The gain in energy or biomass per unit area per unit time remaining after allowing for respiratory losses (R). Other metabolic losses may take place, but these may be ignored when calculating and defining net productivity for the purpose of this course.
productivity, net primary (NPP)	The gain by producers in energy or biomass per unit area per unit time remaining after allowing for respiratory losses (R). This is potentially available to consumers in an ecosystem.
productivity, primary	The gain by producers in energy or biomass per unit area per unit time. This term could refer to either gross or net primary productivity.
productivity, gross secondary (GSP)	The total gain by consumers in energy or biomass per unit area per unit time through absorption.
productivity, net secondary (NSP)	The gain by consumers in energy or biomass per unit area per unit time remaining after allowing for respiratory losses (R).
productivity, secondary	The biomass gained by heterotrophic organisms, through feeding and absorption, measured in units of mass or energy per unit area per unit time.
r-strategists	Species using <i>r</i> -strategies will tend to spread their reproductive investment among a large number of offspring so that they are well adapted to colonize new habitats rapidly and make opportunistic use of short-lived resources.
sere	The set of communities that succeed one another over the course of succession at a given location.

smog	The term now used for any haziness in the atmosphere caused by air pollutants. Photochemical smog is produced through the effect of ultraviolet light on the products of internal combustion engines. It may contain ozone and is damaging to the human respiratory system and eyes.
society	An arbitrary group of individuals who share some common characteristic such as geographical location, cultural background, historical timeframe, religious perspective, value system, etc.
soil	A mixture of mineral particles and organic material that covers the land, and in which terrestrial plants grow.
soil profile	A vertical section through a soil, from the surface down to the parent material, revealing the soil layers or horizons.
speciation	The process through which new species form. (See also evolution .)
species	A group of organisms that interbreed and produce fertile offspring.
stable equilibrium	The condition of a system in which there is a tendency for it to return to a previous equilibrium condition following disturbance.
standing crop	See biomass .
steady-state equilibrium	The condition of an open system in which there are no changes over the longer term, but in which there may be oscillations in the very short term. There are continuing inputs and outputs of matter and energy, but the system as a whole remains in a more-or-less constant state (e.g. a climax ecosystem).
succession	The orderly process of change over time in a community. Changes in the community of organisms frequently cause changes in the physical environment that allow another community to become established and replace the former through competition. Often, but not inevitably, the later communities in such a sequence or sere are more complex than those that appear earlier.
sustainability	Use of global resources at a rate that allows natural regeneration and minimizes damage to the environment. For example, a system of harvesting renewable resources at a rate that will be replaced by natural growth might be considered to demonstrate sustainability.
system	An assemblage of parts and the relationships between them, which together constitute an entity or whole.
system, closed	A system in which energy, but not matter, is exchanged with its surroundings.
system, isolated	A system that exchanges neither matter nor energy with its surroundings.
system, open	A system in which both matter and energy are exchanged with its surroundings (e.g. natural ecosystems).

trophic level

The position that an organism occupies in a food chain, or a group of organisms in a community that occupy the same position in food chains.

zonation

The arrangement or patterning of plant communities or ecosystems into parallel or sub-parallel bands in response to change, over a distance, in some environmental factor. The main biomes display zonation in relation to latitude and climate. Plant communities may also display zonation with altitude on a mountain, or around the edge of a pond in relation to soil moisture.

MATHEMATICAL REQUIREMENTS

All Diploma Programme ecosystems and societies students should be able to:

- perform the basic arithmetic functions: addition, subtraction, multiplication and division
- use simple descriptive statistics: mean, median, mode, range, frequency, percentages, ratios, approximations and reciprocals
- use standard notation (eg 3.6×10^6)
- use direct and inverse proportion
- interpret frequency data in the form of bar charts, column graphs and histograms, and interpret pie charts
- understand the significance of the standard deviation of a set of data
- plot and sketch graphs (with suitable scales and axes)
- interpret graphs, including the significance of gradients, changes in gradients, intercepts and areas
- demonstrate sufficient knowledge of probability (e.g. in assessing risks in environmental impact).

PART 3—SUBMISSION OF INTERNAL ASSESSMENT WORK

SUBMISSION OF INTERNAL ASSESSMENT WORK

Internal Assessment Requirements

At least 20% of teaching time must be devoted to internal assessment activities, excluding time spent writing up work. This equates to 30 hours. Ideally this time should be spread throughout most of the course and not condensed into just a few weeks at the beginning, middle or end of the course. Only 2 to 3 hours of investigative work can be carried out after the deadline for submission of work to the moderator and still be counted as part of the total hours for the practical programme. The activities should ideally include a spread of content material from the subject as a whole.

Practical Scheme of Work

A summary of all the investigative activities carried out by a student is defined as a practical scheme of work. Details are recorded on form ES/PSOW, which can be found on page 72. Each candidate must have a copy of this form. Teachers are free to make their own electronic version of form ES/PSOW provided that it includes all the necessary information.

Completion of Form ES/PSOW

The following information must be entered on form ES/PSOW:

- date(s)—when each investigation was carried out
- outline—a brief description of the investigation
- topic—the number(s) of the corresponding topic(s) or sub-topic(s)
- time—an estimate of the time, in hours, spent by the candidate on the investigation, excluding any write-up time
- levels—the numerical value (0–6) awarded for each criterion
- highest levels—the highest levels achieved in each of the criteria
- total—the sum of the two highest levels achieved in each of the criteria *planning, data collection and processing* and *discussion, evaluation and conclusion* and the level achieved in the criterion *discussion, evaluation and conclusion*. The maximum total possible is 42.

Each of the criteria *planning*—PI, *data collection and processing*—DCP, and *discussion, evaluation and conclusion*—DEC must be assessed on at least two occasions, indicated by levels 0–6 on form ES/PSOW. The criterion *personal skills* - PS is assessed **summatively** once only at the end of the course. This summative judgement takes into account the candidate's performance over several pieces of work. It should:

- not be the average achieved over the whole Practical Scheme of Work
- reflect any sustained improvement in performance.

For the criteria PI, DCP and DEC, the two highest levels achieved must be circled or highlighted on form ES/PSOW for each candidate in the sample. Similarly, the level achieved for PS must also be circled/highlighted. Teachers must assess the work to be re-marked by the moderator using the criteria and achievement level matrix on pages 15-17. Apart from this, teachers are free to use whatever system of marking and reporting that is appropriate to their candidates.

The Moderation Sample

Teachers must refer to section F of the *Vade Mecum* for general information on internal assessment, including the selection of sample work and the completion of the combined IA/PG marksheet.

The Purpose of Moderation

Teachers are required to submit a sample set of candidates' work for the purpose of moderation. The moderator will re-mark this work to ensure an equivalent standard between schools. All schools will receive feedback on the suitability of the investigations for assessment against the criteria and on the practical scheme(s) of work. The feedback form cannot comment on how well the school's marking agreed with the external IBO standard because the moderator completing the form is also subject to moderation.

For each candidate in the sample set, the following materials must be sent to the moderator:

- a form ES/PSOW
- the write-ups, instruction sheets and/or summaries of verbal instructions corresponding to the highest levels circled/highlighted on form ES/PSOW for the criteria *planning, data collection and processing*, and *discussion, evaluation and conclusion*. No written evidence is required for *personal skills*. Any photocopied material submitted must be legible. Ideally, original work should be sent to the moderator.

Where two or more teachers are responsible for the internal assessment of candidates, internal standardization must take place before submission of work to the moderator.

Atypical Candidates

Schools with small subject entries may have to include the work of atypical candidates in their sample. Teachers should annotate the work of such candidates to indicate that it is atypical and state the nature of the difficulty/problem.

Submission of IA/PG Information

Please see section F of the *Vade Mecum* for information relating to the recording and submission of IA/PG data.

Summary of Arrival Dates

- **10 April** for the May examination session (**10 October** for the November examination session) - submission of IA/PG data to IBCA
- **20 April** for the May examination session (**20 October** for the November examination session) - submission of sample assessment work to the moderator



International Baccalaureate - Form ES/PSOW

Internal assessment cover sheet: ecosystems and societies

SUBMIT TO: **MODERATOR** ARRIVAL DATE: **20 APR (20 OCT)** SESSION:

SCHOOL NUMBER: SCHOOL NAME:

• Type or write legibly using black ink and retain a copy of this form.

CANDIDATE NAME: SESSION NUMBER:

Date(s)	Outline of investigations (include title, a brief description and internal school coding if used)	Topic/ option (hrs)	Levels Awarded			
			PI	DCP	DEC	PS

* The two highest levels achieved in PI, DCP and DEC, and the level achieved in PS.

Two highest levels achieved*:						
TOTAL						

This total must also be entered on IBIS

To be completed by teacher Name: Signature: Date:

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IBO Online

- Main web site—<http://www.ibo.org>
- Online curriculum centre for IB teachers (password protected)—<http://.online.ibo.org>

Regional Offices

Regional offices of the IBO around the world provide services to authorized schools, arrange teacher training events and conferences, and assist schools in communications with the IBO headquarters in Geneva and the Curriculum and Assessment Centre in Cardiff.

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