Course notes

International Baccalaureate · IB Diploma · Environmental Systems and Societies · HL

IB IB Diploma · Environmental Systems and Societies · HL: teaching notes

Version: First assessment 2026

These notes cover selected topics of the course; they are not the whole specification.

Assessment and course boundaries

- ESS integrates ecological evidence with human values, systems and sustainability; it is not a generic Biology course.
- HL adds environmental law, environmental/ecological economics and ethics as lenses integrated with topic evidence, alongside deeper topic coverage.
- Both levels have practical work 30 h, collaborative sciences project 10 h and individual investigation 10 h. Use school-approved fieldwork and ethical social-data collection.
- Written assessment and investigation details are recorded from the 2026 brief; the old SL-only 2017 brief is not the current course.
- 2026 assessment: SL Paper 1 is 1 h/25%, Paper 2 is 2 h/50%, investigation 25%; HL Paper 1 is 2 h/30%, Paper 2 is 2.5 h/50%, investigation 20%. Paper 1 uses an unseen case study; Paper 2 has short/data questions and structured essays. The individual investigation is a real student-formulated inquiry, 10 h and a maximum 3,000-word report.

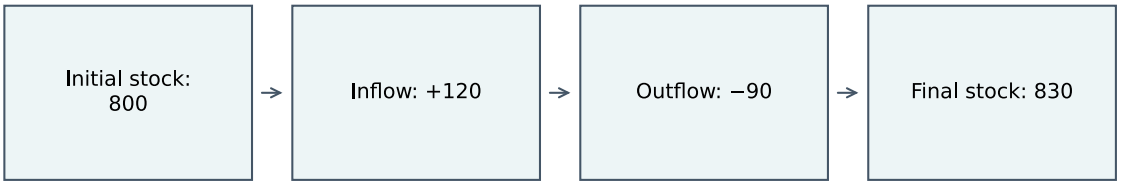
Environmental systems, feedback and perspectives

Official-unit focus: 1 Foundation; 2 Ecology

A lake can respond to the same nutrient input differently depending on its current state. Environmental outcomes depend on stocks, flows and feedback.

A system model has a boundary, stores and flows. Negative feedback counteracts change; positive feedback amplifies it. An environmental perspective shapes what people value and which management outcomes they prioritize.

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Separate physical evidence from value judgements. A stock is an amount at a time; a flow is an amount per time. Sustainability decisions require ecological, social and economic evidence and a stated scale.

Draw the system boundary before calculating a budget. Identify inflows, outflows and possible unmeasured terms. Compare stakeholder claims using the same evidence, then explain where values lead to different choices.

■ Checked worked case

Known: a reservoir begins with 800 units, receives 120 and loses 90 during a week. Change in storage = inflow-outflow = 120-90 = 30. Final storage = 800+30 = 830 units. The model assumes no omitted flow.

■ Common error

A balance that closes mathematically can still omit a real process if terms were estimated to fit. Positive feedback does not mean a socially desirable result.

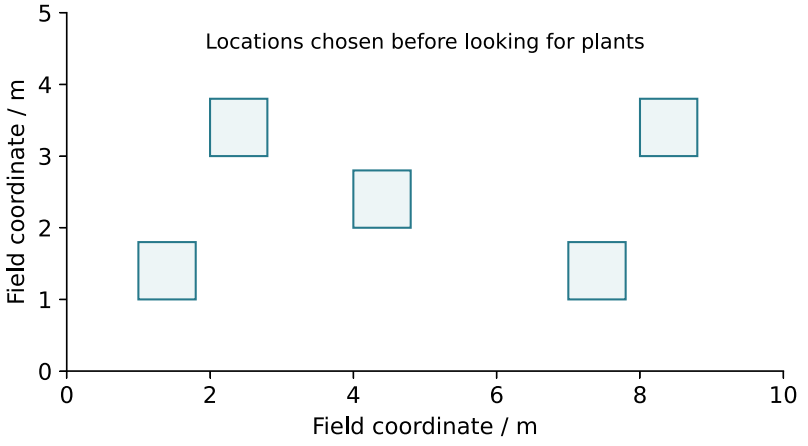
Sampling populations without choosing the answer

Official-unit focus: 2 Ecology

A field edge looks richer in plants than its centre. Choosing only the richest patches would build the desired result into the sampling method.

A population consists of organisms of one species in a defined area. Random quadrats estimate density without deliberately selecting patches. A transect investigates change along an environmental gradient.

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Estimate total abundance by multiplying mean density by area, with consistent units. This assumes sampled areas represent the habitat. Patchiness and too few samples widen uncertainty.

Choose coordinates with random numbers before visiting the patches. Record quadrat area and counting rules. For a transect, use fixed distances and measure a relevant abiotic variable. Do not damage habitats or sample unsafe locations.

■ Checked worked case

Known: five 0.25 square metre quadrats contain 3, 4, 6, 5 and 2 plants. Mean count $= 20/5 = 4$. Density $= 4/0.25 = 16$ plants per square metre. Estimated abundance in 100 square metres $= 16 \times 100 = 1{,}600$ plants.

■ Common error

Quadrats suit organisms that do not move quickly. A food chain arrow shows the direction of energy transfer, not the direction a predator travels.

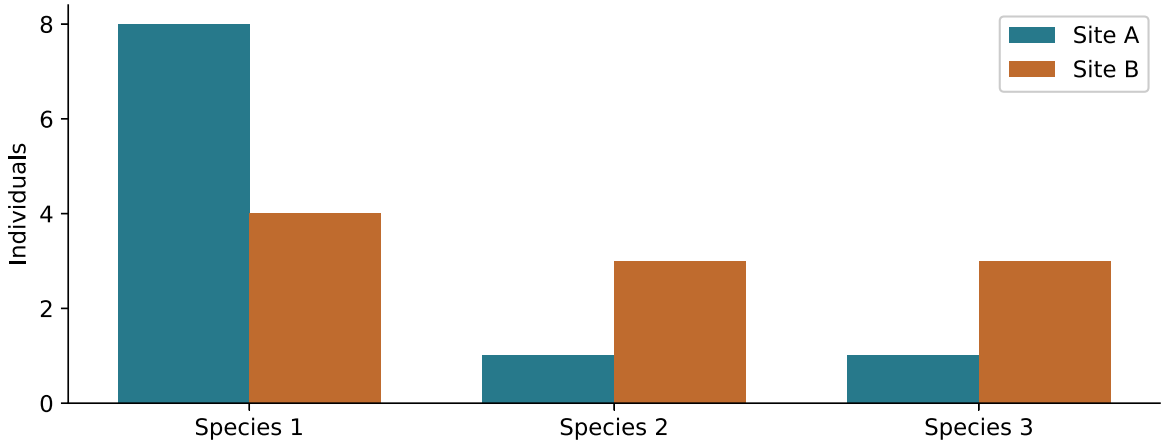
Biodiversity, conservation and sampling evidence

Official-unit focus: 3 Biodiversity and conservation

A site with many individuals can still be dominated by one species. Abundance, richness and evenness describe different features of biodiversity.

Species richness counts species. Evenness concerns relative abundance. Conservation can protect habitats, populations or genetic diversity; a management judgement must state the conservation goal.

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Compare surveys with similar area, effort, season and identification rules. A diversity index is meaningful only with its formula and conventions specified. Habitat fragmentation can affect movement and gene flow even when total area changes little.

Use non-destructive field sampling approved by the school. Identify organisms with a suitable key and record uncertain identifications rather than inventing species. Combine ecological evidence with stakeholder perspectives on land use.

■ Checked worked case

Known: site A has counts 8, 1 and 1; site B has 4, 3 and 3. Both have richness 3 and total abundance 10. The most abundant species occupies 80% in A and 40% in B. B is more even under these counts.

■ Common error

An index cannot by itself explain the cause of a difference. A newly recorded species may reflect improved observation rather than a recent ecological arrival.

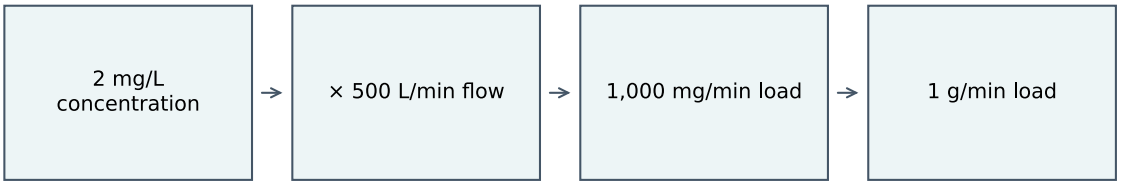
Water, pollution and management trade-offs

Official-unit focus: 4 Water

A downstream sample has less dissolved oxygen after a nutrient input. The explanation must connect biological processes with the water-system evidence.

Eutrophication can begin with nutrient enrichment, followed by greater producer growth and increased decomposition after organisms die. Decomposer respiration can lower dissolved oxygen. Water availability depends on quantity, quality and access.

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Distinguish concentration from total pollutant load. Dilution can reduce concentration without removing the pollutant mass. A management plan should consider upstream causes, users and effects on other parts of the catchment.

Collect approved water-quality observations at matched sites and times. Use calibrated instruments and consistent sampling depth. Avoid contact with contaminated water and do not infer potability from clarity.

■ Checked worked case

Known: concentration is 2 mg per litre and flow is 500 litres per minute. Load = concentration × flow = 2×500 = 1,000 mg per minute = 1 g per minute. A lower concentration during high flow can still produce a high total load.

■ Common error

Clear water is not necessarily safe water. Nutrient enrichment does not directly use up oxygen; the pathway includes biological activity and decomposition.

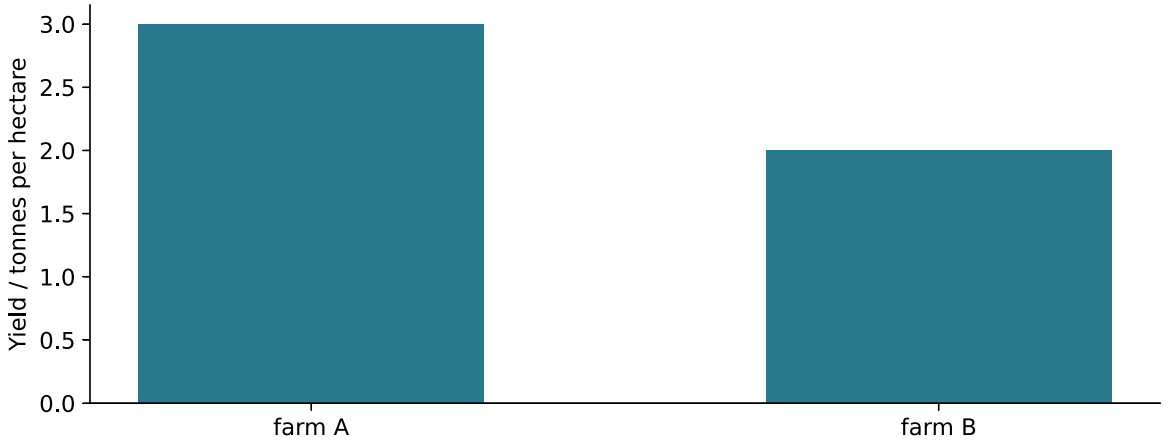
Land, food and resource decisions

Official-unit focus: 5 Land; 7 Natural resources

A farm can increase yield while increasing soil loss or water demand. Food-system evaluation requires more than tonnes harvested.

Soil supports nutrient cycling, water storage and organisms. Erosion removes soil; nutrient depletion changes fertility. Resource use involves extraction, production, distribution and waste.

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Distinguish total yield from yield per area and energy input. Sustainable management must consider regeneration rates and impacts beyond the farm boundary. Different stakeholders may rank food security, biodiversity and income differently.

Compare management options using a stated functional unit and the same timescale. Use approved secondary datasets or non-destructive soil observations. Explain trade-offs instead of claiming a method has no disadvantages.

■ Checked worked case

Known: farm A harvests 18 tonnes from 6 hectares. Yield per area = 18/6 = 3 tonnes per hectare. Farm B harvests 20 tonnes from 10 hectares, so its yield is 2 tonnes per hectare despite a larger total harvest.

■ Common error

A high yield is not proof of long-term soil health. Renewable resources can be depleted when use exceeds regeneration.

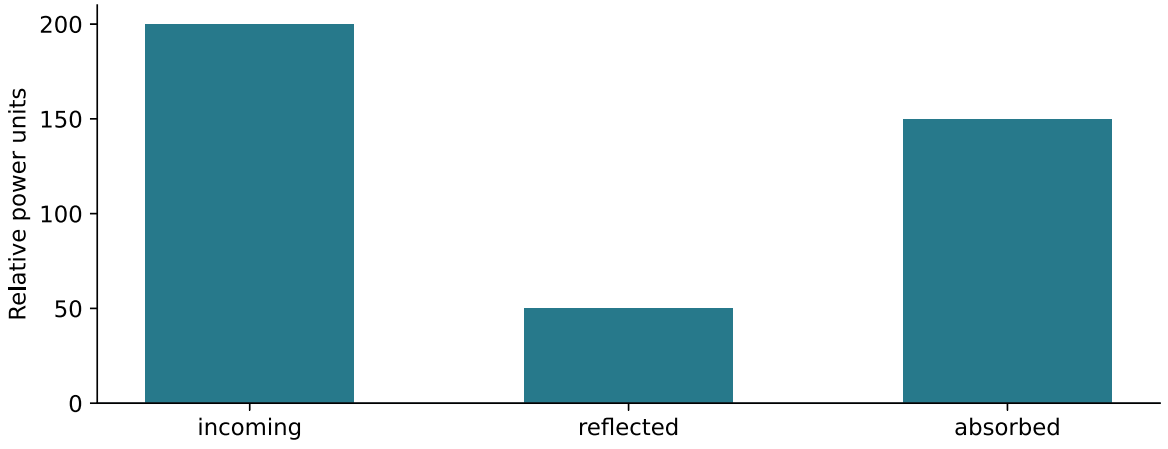
Climate evidence, energy budgets and policy

Official-unit focus: 6 Atmosphere and climate change

One cold day does not disprove a warming climate. Weather describes short-term conditions; climate describes distributions over longer times and regions.

The Earth energy balance includes incoming solar radiation, reflection, absorption and outgoing infrared radiation. Greenhouse gases absorb and emit infrared radiation. Feedback can alter the response to an initial forcing.

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Distinguish mitigation, which addresses drivers, from adaptation, which reduces harm from impacts. A policy assessment needs evidence about effectiveness, cost, equity and uncertainty; one criterion is not the entire decision.

Compare multi-year data using consistent baselines. State the region, timescale and uncertainty. At HL, connect a management decision to law, economics and ethics rather than treating these lenses as extra definitions only.

■ Checked worked case

Known: a surface receives 200 power units and reflects 50. Absorbed input = incoming-reflected = 200-50 = 150. Reflected fraction = 50/200 = 0.25 = 25%. A change in reflectivity alters the absorbed budget under this model.

■ Common error

The greenhouse effect is not the same process as ozone depletion. A carbon footprint estimate depends on its system boundary.

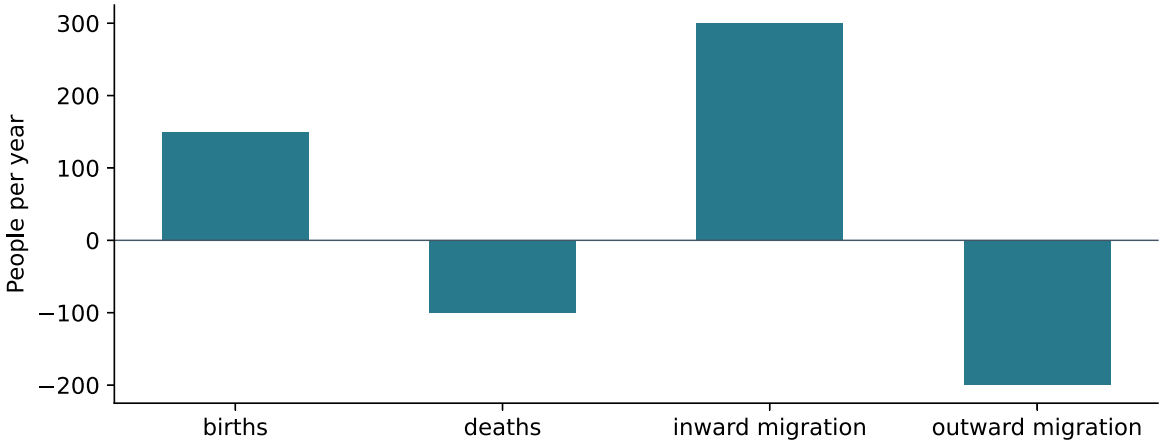
Population, urban systems and indicators

Official-unit focus: 8 Human populations and urban systems

A city can grow because people move into it even when births equal deaths. Population change has several flows.

Population change depends on births, deaths, immigration and emigration. Urban systems exchange energy, materials and waste with a wider region. A sustainability indicator measures a specified feature rather than total wellbeing.

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Compare rates with a common denominator and interval. An average can hide unequal access to services. At HL, evaluate how economic incentives, legal responsibilities and ethical priorities change an urban management proposal.

Use published demographic and city-service data with dates and definitions. Protect privacy when collecting local opinions. Compare the same geographical boundary rather than mixing an urban core with a whole metropolitan region.

■ Checked worked case

Known: a city has 10,000 people; births 150, deaths 100, immigration 300 and emigration 200 in one year. Change = 150-100+300-200 = 150. Growth percentage = 150/10,000×100 = 1.5%.

■ Common error

A projected population is conditional on assumptions. Urban growth does not automatically mean improved health, income or environmental quality for every resident.

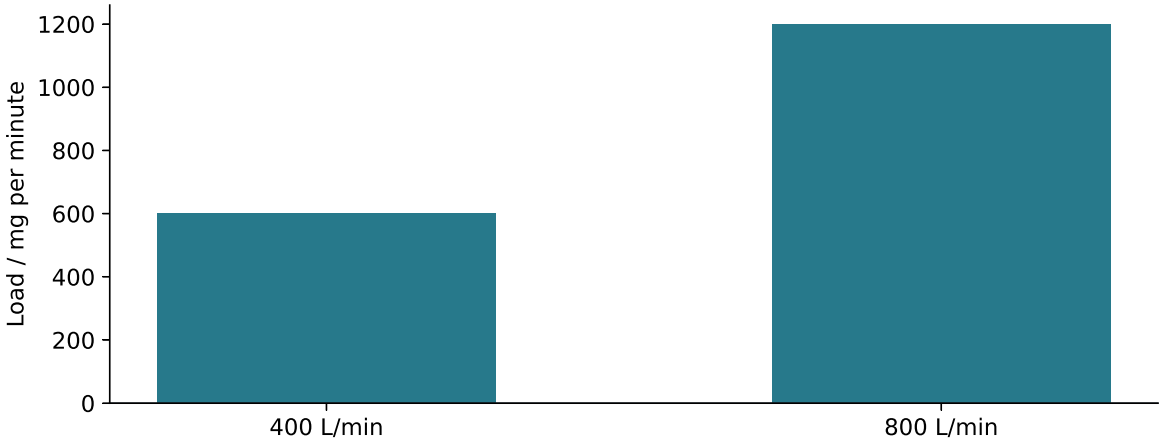
Environmental law: rules, evidence and enforcement

Official-unit focus: HL.a Environmental law

Two catchments have the same discharge limit but different water quality. A legal rule can influence behaviour only through its coverage, implementation and enforcement.

Environmental law defines obligations and permissions within a jurisdiction. A discharge permit may specify a concentration, a total load, monitoring and consequences of non-compliance. International agreements require implementation through institutions; signing an agreement alone does not show that an environmental outcome has improved.

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Distinguish the legal instrument from the evidence about its effect. A concentration limit can be satisfied while total pollutant load rises if flow increases. Evaluate monitoring coverage, detection probability, incentives, access to justice and effects on different groups. An observed change after a policy is compatible with an effect but also with rainfall, industrial changes or other interventions.

Use an attributed historical or clearly fictional permit and paired monitoring data. Identify the regulated activity, responsible authority, geographical boundary and date. Compare upstream/downstream and before/after observations where available, document sampling gaps, and discuss whose evidence or costs are excluded. Do not present this classroom model as advice about current local law.

■ Checked worked case

Known: a fictional permit caps discharge at 2 mg/L. A monitored discharge is 1.5 mg/L at 400 L/min. Load = concentration × flow = 600 mg/min. At the same concentration and 800 L/min the load is 1,200 mg/min. Both concentration observations satisfy the fictional cap, while the second transports twice the mass.

■ Common error

Compliance with one indicator does not prove ecological safety or fair enforcement. Compare actual outcomes with the policy objective and consider both administrative feasibility and affected communities.

Environmental economics: costs beyond the market price

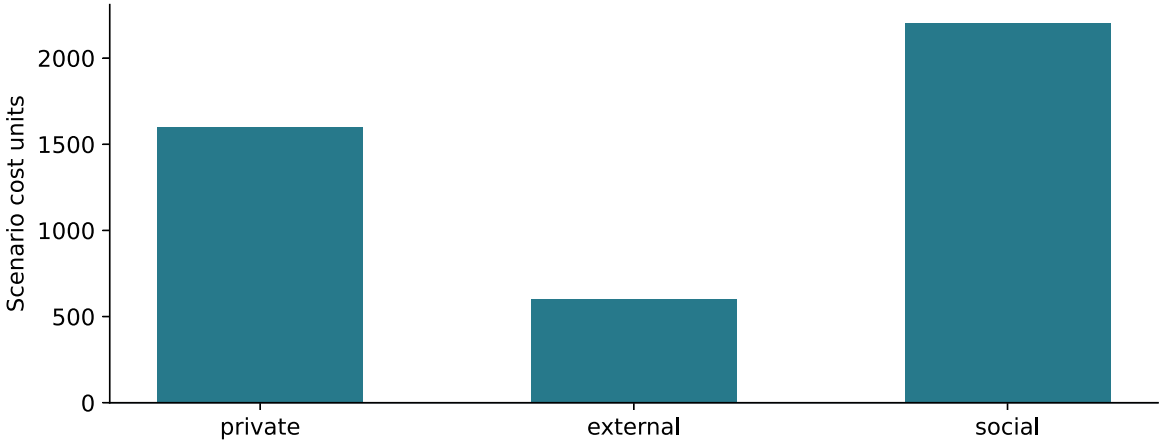
Official-unit focus: HL.b Environmental and ecological economics

A cheap product can impose waste or pollution costs on people who did not buy it. Its market price may omit part of its environmental cost.

An externality is a cost or benefit affecting a third party that is not fully reflected in a transaction. Environmental economics examines incentives and valuation, including instruments such as taxes, subsidies and tradable permits. Ecological economics

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also questions growth assumptions and emphasizes ecological limits and relationships between the economy and its supporting systems.



In a simplified model, marginal social cost equals marginal private cost plus marginal external cost. A pollution charge can alter incentives, but selecting a charge requires evidence and a stated objective. Monetary totals do not by themselves settle distribution, irreversibility, uncertainty or whether a service can be substituted.

Construct a transparent table with a common currency, time period and system boundary. Separate measured expenditure from estimated environmental damage. Compare at least two valuation assumptions, identify who pays and who benefits, and consider a non-monetary indicator such as habitat condition. Label these as classroom scenarios rather than forecasts.

■ Checked worked case

Known: producing one item costs the producer 8 units, while the scenario estimates an external cost of 3 units. Social cost is 11 units per item. For 200 items, private cost is 1,600 units and estimated external cost is 600 units, giving 2,200 units total under this model. If external damage is estimated at 1–5 units per item, the social-cost range is 1,800–2,600 units.

■ Common error

A money value is an assumption-dependent estimate, not a measurement of intrinsic ecological value. A policy that lowers total cost can still place a disproportionate burden on a vulnerable group.

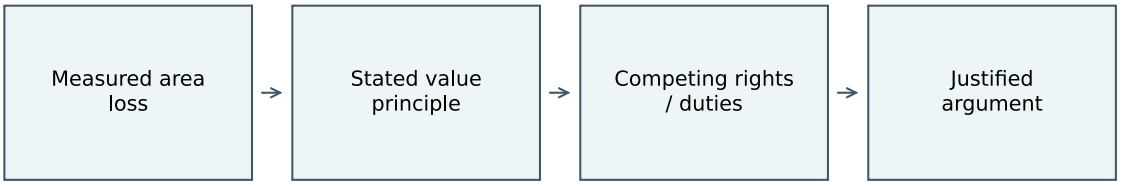
Environmental ethics: make the value judgement explicit

Official-unit focus: HL.c Environmental ethics

People may agree on the measured loss of a wetland but disagree on whether a development is acceptable. The disagreement can concern values as well as scientific uncertainty.

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Environmental ethics examines reasons for responsibilities toward people, other organisms and ecological systems. Anthropocentric reasoning emphasizes human interests; biocentric reasoning recognizes moral standing of living organisms; ecocentric reasoning emphasizes ecological wholes. These positions are lenses for analysing arguments, and real individuals can combine them.



Separate descriptive claims from normative claims. A species count is evidence about the sampled community; deciding that every species has intrinsic value is a value position. Compare consequences, rights, duties and fairness across generations. A defensible argument states its values, uses accurate evidence and acknowledges competing claims rather than disguising a value choice as a calculation.

Use a fictional planning dispute or an attributed historical case. Build an argument table: stakeholder, factual claim, evidence, value principle and possible response. Include affected communities and future generations without pretending to speak for them. Use voluntary anonymous classroom positions; assess the reasoning rather than agreement with a preferred worldview.

■ Checked worked case

Known: a wetland proposal affects 12 hectares of a 60-hectare site, or 20%. This quantifies the stated area change. An anthropocentric argument might examine flood protection and livelihoods; a biocentric argument might consider affected organisms; an ecocentric argument might consider hydrological connections. The 20% figure cannot alone decide which ethical argument is strongest.

■ Common error

Worldview labels are analytical aids, not fixed stereotypes of cultures or people. Neither a stakeholder majority nor a numerical index automatically resolves a rights-based or intergenerational objection.

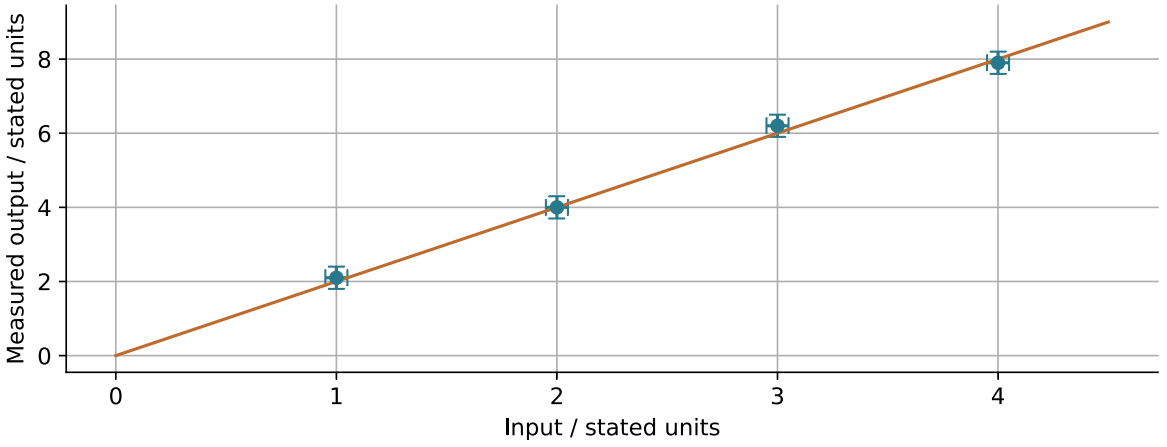
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Uncertainty, gradients and model testing

Official-unit focus: Practical Experimental programme

A line passing near every data point is useful, but its gradient can still be uncertain. A graph is evidence for a model within the measurement range.

Random variation makes repeated readings differ. Systematic error shifts results consistently. Absolute uncertainty has the measured unit; relative or percentage uncertainty compares uncertainty with the measured value.



For a product or quotient, adding fractional uncertainties is a common maximum-uncertainty approximation. For a difference, add absolute uncertainties. A nonzero intercept can reveal an offset or an incomplete model.

Show units on axes and choose a sensible scale. Plot uncertainty bars where justified, draw a best-fit line rather than joining every point, and estimate steepest and shallowest plausible gradients when the course method calls for them.

■ Checked worked case

Known: length = 50.0 mm with uncertainty 1.0 mm. Percentage uncertainty = absolute uncertainty/value $\times 100 = 1.0/50.0 \times 100 = 2.0\%$. For a quotient of two independently measured quantities with maximum percentage uncertainties 2% and 3%, the summed maximum estimate is 5%.

■ Common error

Repeating readings reduces random uncertainty in a mean but does not automatically remove a zero error. Do not quote more decimal places than your measurement can support.

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