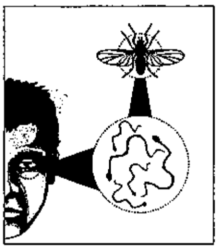
BEYOND PHYSICS AS FACT
PREPARING RICH CURRICULUM UNITS

UNIT 1: LIGHT & SIGHT IN FOCUS

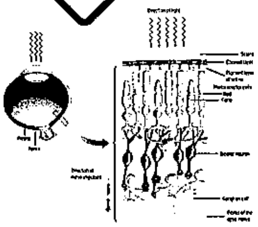
CONNECTEDNESS

HEALTH & SOCIAL EDUCATION
Responsible action about health and social issues



What are we doing to reduce visual impairment and blindness in the world?

RESULTS



KEY IDEAS
The way people lose their sight and possible treatments

- How light travels
- Mirrors & lenses
- emr and colour
- Eye.

UNIT 6: TRANSFORMATION BY STEAM

HUMAN INGENUITY
Creating solutions & their impact on society & environments.

CONNECTEDNESS

How have scientific inventions led to major changes in society?

Internet search 16th century mining

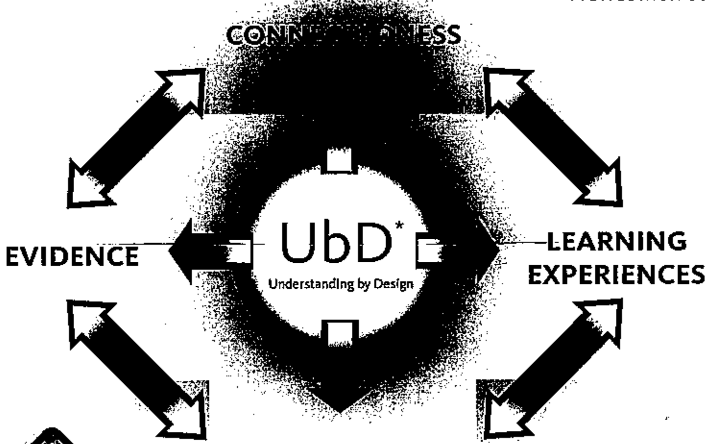
LEARNING EXPERIENCES

AREA OF INTERACTION (IBMYP)

Social & personal meaning

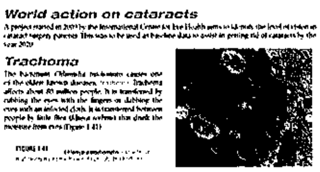
Watt on stage
Produce a theatrical piece that demonstrates the innovations James Watt made to the Newcomen steam engine.

CONNECTEDNESS



Assessment: understanding & proficiency

Knowledge: facts, concepts, principles Skills: processes, procedures, strategies.



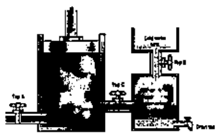
CONNECTEDNESS

What should students know, understand & be able to do?

KEY IDEAS
The development of the steam engine, which led to many changes in society

- Energy
- Heating & cooling
- Temperature
- Pressure.

RESULTS

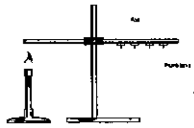


KEY IDEAS (IBMYP)

SUMMATIVE ASSESSMENT TASK
Organise World Sight Day event

- Improve conditions
- Show how scientific knowledge is used.

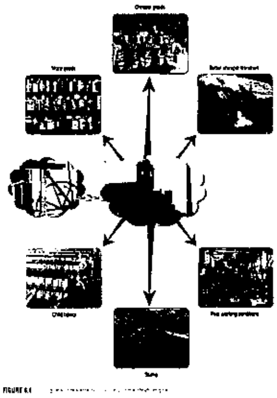
EVIDENCE

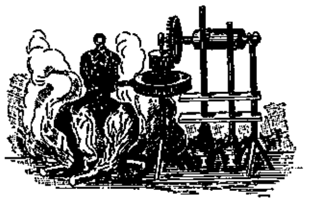


Heat conduction

Energy transfer and temperature change

Practical activities
- Eye dissection
- Mixing colours.





Turbines

IBMYP Science Assessment
A One World: interdependence of science and society.
B Communication: accurate information in a variety of genres.
C Knowledge and understanding: use of ideas in familiar and unfamiliar situations.
D Scientific inquiry: design and conduct investigations.
E Processing data: sift, sort and report data in a variety of forms.
F Attitudes in science: safety, respect, collaboration.

EVIDENCE

References
Wiggins, Grant and Jay McTighe (2006), *Understanding by Design*, Pearson, NJ. and (2004) *Understanding by Design: Professional Development Workbook*, Association for Supervision and Curriculum Development, Virginia, USA.
International Baccalaureate Organisation (2008), *Middle Years Program MYP: From principles into practice*, Cardiff, UK.

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References
Armstrong, Rick, Neil Champion and others (2010), *Science for the International Student 4/5: Physics*, Nelson Cengage Learning, Melbourne, Unit 1, Light and sight in focus, 1-38, and Unit 6, Transformation by steam, 177-212

Entry Points for the Design Process

Important topic or content

- What Big Ideas either underlie this topic or emerge from studying it?
- Why is it so important?

Established goals or content standards

- What Big Ideas are embedded in this goal?
- What will students need to understand to *really* learn this?

An important skill or process

- What will this skill enable students to do?
- What will students need to understand to effectively apply this skill?

Stage 1—Desired Results

Stage 2—Assessment Evidence

Stage 3—Learning Plan

- What will students need to understand to perform well on this test?
- What other evidence of learning is needed?

A significant test

- Exactly *why* are we having students read this text or use this resource?
- What Big Ideas do we want students to understand as a result?

A key text or resource

- What Big Ideas will students come to understand as a result of this activity or unit?
- What evidence of understanding is needed?

A favorite activity or familiar unit

1-Page Template with Questions

Stage 1—Desired Results

Established Goals: (G)

- What relevant goals (e.g., content standards, course or program objectives, learning outcomes) will this design address?

Understandings: (U)

Students will understand that . . .

- What are the big ideas?
- What specific understandings about them are desired?
- What misunderstandings are predictable?

Essential Questions: (Q)

- What provocative questions will foster inquiry, understanding, and transfer of learning?

Students will know . . . (K)

Students will be able to . . . (S)

- What key knowledge and skills will students acquire as a result of this unit?
- What should they eventually be able to do as a result of such knowledge and skill?

Stage 2—Assessment Evidence

Performance Tasks: (T)

- Through what authentic performance tasks will students demonstrate the desired understandings?
- By what criteria will performances of understanding be judged?

Other Evidence: (OE)

- Through what other evidence (e.g., quizzes, tests, academic prompts, observations, homework, journals) will students demonstrate achievement of the desired results?
- How will students reflect upon and self-assess their learning?

Stage 3—Learning Plan

Learning Activities: (L)

What learning experiences and instruction will enable students to achieve the desired results? How will the design

W = Help the students know Where the unit is going and What is expected? Help the teacher know Where the students are coming from (prior knowledge, interests)?

H = Hook all students and Hold their interest?

E = Equip students, help them Experience the key ideas and Explore the issues?

R = Provide opportunities to Rethink and Revise their understandings and work?

E = Allow students to Evaluate their work and its implications?

T = Be Tailored (personalized) to the different needs, interests, and abilities of learners?

O = Be Organized to maximize initial and sustained engagement as well as effective learning?

Unit 3: How does energy relate to nature?

AREA OF STUDY 1

How do things move when there is no contact?

In this area of study, students examine the similarities and differences between three fields: gravitational, electrical and magnetic. Field models are used to explain the motion of objects when there is no apparent contact. Students learn that positions in fields determine the potential energy of an object and the force on an object. They investigate how concepts related to field models can be applied to make motors and to accelerate particles through contexts including digital cameras, The Australian Synchrotron and the Large Hadron Collider.

Outcome 1

On completion of this unit the student should be able to analyse gravitational, electrical and magnetic fields, and use these to explain the operation of motors and particle accelerators.

Key knowledge

Fields and interactions

- describe gravitation, magnetism and electricity using a field model
- compare gravitation, magnetic and electric fields including directions and shapes of fields, attractive and repulsive fields, dipoles and monopoles.
- compare gravitational fields and electric fields about a point mass or charge (positive or negative) in terms of
  - — the direction of the field
  - — the shape of the field
  - — the use of the inverse square law to determine the magnitude of the field
  - — qualitatively, potential energy changes associated with a point mass or charge moving in the field
- apply a vector field model to magnetic phenomena including shapes and directions of fields produced by bar magnets, and by current-carrying wires, coils and solenoids
- identify fields as static or changing, and uniform or non-uniform.

Effects of fields

- analyse the use of a uniform electric field to accelerate a charged particle including
  - electric field and electric force concepts using: $E = k\frac{Q}{r^2}$ and $F = k\frac{q_1 q_2}{r^2}$
  - potential energy changes in a uniform field: $W = qV$, $E = \frac{V}{d}$
  - the magnitude of the force on a charged particle: $F = qE$
- analyse the use of a magnetic field to change the path of a charged particle including
  - the magnitude and direction of the force applied to an electron beam by a magnetic field: $F = qvB$ in cases where the directions of v and B are perpendicular or parallel
  - the radius of the path followed by a low-velocity electron in a magnetic field: $qvB = \frac{mv^2}{r}$
- analyse the use of gravitational fields to accelerate mass including
  - gravitational field and gravitational force concepts using: $g = G\frac{M}{r^2}$ and $F_g = G\frac{m_1 m_2}{r^2}$
  - potential energy changes in a uniform field: $E_g = mg\Delta h$
  - gravitational potential energy from area under force-distance graph and area under field-distance graph multiplied by mass

Application of field concepts

- apply the concepts of force due to gravity, F_g, and normal reaction force, F_N, including satellites in orbit where the orbits are assumed to be uniform and circular
- model satellite motion (artificial, moon, planet) as uniform circular orbital motion: $a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$
- describe the interaction of two fields, allowing that electric charges, magnetic poles and current carrying conductors can either attract or repel, whereas masses only attract each other
- analyse the force on a current carrying conductor due to an external magnetic field; $F = nIlB$ where the directions of I and B are either perpendicular or parallel to each other
- analyse the operation of simple DC motors consisting of one coil, containing a number of loops of wire, which is free to rotate about an axis in a uniform magnetic field and including the use of a split ring commutator
- apply field concepts to mass spectrometers and accelerators including The Australian Synchrotron and the Large Hadron Colllider.

1-Page Template

Stage 1—Desired Results	
Established Goals: (G)	
Understandings: (U) *Students will understand that . . .*	**Essential Questions:** (Q)
Students will know . . . (K)	*Students will be able to . . .* (S)
Stage 2—Assessment Evidence	
Performance Tasks: (T)	**Other Evidence:** (OE)
Stage 3—Learning Plan	
Learning Activities: (L)	

Unit 4: Why are light and matter so challenging to explain?

AREA OF STUDY 3

Student-designed practical investigation

A student-designed practical investigation related to waves, fields or motion is to be undertaken in either Unit 3, Unit 4 or across Units 3 and 4. The investigation should relate to ideas and skills developed across Units 3 and 4 and should be investigated directly by the student though practical work.

The investigation requires the student to ask a question, formulate a hypothesis, plan a course of action that attempts to answer the question and that takes into account safety and ethical considerations, undertake an experiment which involves the collection of primary quantitative data, analyse and evaluate the data, identify limitations of data and methods, link experimental results to science ideas, reach a conclusion in response to the question and suggest further investigations which may be undertaken. Results should be communicated in a scientific poster format according to a template which is included below and elaborated in the *Advice for teachers*. A practical logbook should be maintained by the student for record, authentication and assessment purposes.

Outcome 3

On completion of this unit the student should be able to design and undertake an investigation related to waves, fields or motion, and present methodologies, findings and conclusions as a scientific poster.

To achieve this outcome the student will draw on key knowledge outlined below and the related key science skills on pages 9 and 10.

Key knowledge

- concepts specific to the investigation and explanation of their significance, including definitions of key terms, and physics representations
- characteristics of scientific research methodologies and techniques of primary qualitative and quantitative data collection relevant to the selected investigation, including consideration of repeatability, reproducibility, reliability and validity of data, and identification of systematic error
- identification and application of relevant health and safety guidelines
- methods of organising, analysing and evaluating primary data: relevant descriptive statistics and their limitations; sources of uncertainty; limitations of data and methodologies
- use of models in organising and understanding observed phenomena and physics concepts, and their limitations
- key findings of the selected investigation and their relationship to key physics concepts
- nature of evidence that supports or refutes a hypothesis
- conventions of scientific report writing and scientific poster presentation, including correct physics language, symbols, equations, SI units of measurement, significant figures, representations, standard abbreviations, and correct acknowledgement of references.

Outcome 3 Design and undertake an investigation related to waves, fields or motion, and present methodologies, findings and conclusions as a scientific poster.	30	For Outcome 3: Structured scientific poster according to VCAA template (maximum 1000 words)
Total marks	**90**	

*School-assessed Coursework for Unit 4 contributes 20 per cent.

Unit 4 Outcome 3 – Investigation presented as a scientific poster

Unit 4 Outcome 3 requires that students communicate investigation findings as a scientific poster. The poster may be produced electronically or in hard copy format, and should not exceed 1000 words. Students must select information carefully so that they meet the word limit. The production quality of the poster will not form part of the assessment.

The following template provides details about construction of the poster by students and assessment of the poster by teachers.

1-Page Template

Stage 1—Desired Results

Established Goals: G

Understandings: U
Students will understand that . . .

Essential Questions: Q

Students will know . . . K

Students will be able to . . . S

Stage 2—Assessment Evidence

Performance Tasks: T

Other Evidence: OE

Stage 3—Learning Plan

Learning Activities: L

Australian Institute of Physics 19th National Congress: Session 109.00

Beyond physics as fact: preparing rich curriculum units

Neil Champion

Williamstown High School

The poster shows the backwards design processes [1] involved in developing two units for the International Baccalaureate Middle Years Program (IBMYP) [2]. Backwards design focuses attention on rich, engaging and authentic summative assessment tasks. These assist in driving the (non-linear) selection of content, activities, practical work, research projects and formative assessment tasks, as well as more limited summative tasks.

In IBMYP Science there are seven Areas of interaction, the two presented in the poster being Health and social education, which teaches optics through vision and vision impairments and Human ingenuity, which uses a social history approach to thermodynamics. Each unit has a main question and a complex summative assessment task presented at the start.

Features of the units include a broad question with a complex summative assessment task that serve to drive the unit along. These are supported by teaching and learning activities that promote cooperative learning, deep understanding, practical skills, qualitative and quantitative problem-solving and practical inquiry activities that require student initiative. Students are encouraged to reflect on their own learning and to pursue links between the unit's Area of interaction and other big picture Areas of interaction. Opportunities to sift and sort information from the Internet are included.

The effects of science and technology on society are integral to the units so that students are not subjected to a dusty, positivist view of science devoid of moral compass.

*   *   *   *   *   *   *   *   *   *   *   *   *

The poster's four-sided central icon shows the three stages of backward design (Wiggins and McTighe 2006:17-23) and the IBMYP requirement that science students be connected to the world through different Areas of interaction (IBO 2008: 20-33). Subsidiary icons take their cue from the central icon. They are used to link some features of the units to the overall design process.

Understanding by Design (UbD)

The three stages of backward design comprise:

1. **Identify desired results.**
   The emphasis is on the "enduring" understandings that underpin the unit. Prevailing standards and a desire to engage students in worthwhile understandings help drive decisions that prioritize those concepts, learnings and values that students should know, understand, and be able to do.
2. **Determine acceptable evidence.**
   Data that will demonstrate understandings and proficiency is explicitly considered at the outset, not as a final thought somewhere near the end of the unit. As the set of enduring understandings is decided and prioritized, so the question of what will constitute appropriate assessment evidence, and how students will be engaged in the production of authentic responses takes shape.
3. **Plan learning experiences and instruction.**
   Once the desired results and assessment data tools are clarified, the "big ideas" can be broken down into the required knowledge and skills, into facts, concepts and principles on the one hand, and processes, procedures and strategies on the other.

"Backward design may be thought of ... as purposeful task analysis: Given a worthy task to be accomplished, how do we best get everyone equipped?"

Backward design is not a linear process. Teachers do not come to design cold. They already know much about the knowledge and skills of the area of study they wish to plan. They have ideas about appropriate assessment tasks. They are cognizant of the external standards that students are expected to attain. Nevertheless, this process is quite different from two kinds of aimlessness that beset traditional processes: activity-oriented design and coverage. Activity-oriented design focuses on things for students to do without asking whether these lead to worthwhile construction of meaning. Coverage design insists that every fact that needs to be learned is "in the course" without asking if deep learning can be achieved.

International Baccalaureate Middle Years Program

The fourth design pillar in the central icon is *Connectedness*. It points to units based on two of the five IBMYP Areas of interaction.

Areas of interaction

1. **Health and social education.**
   Students learn about pressing health and social issues, the role of science in their solution, and develop skills to take ethical action.
2. **Human ingenuity.**
   Students learn about the way humans have influenced the world, for good and bad, by finding solutions and causing problems.

The other IBMYP Areas of interaction are: Approaches to learning (see session 106.00), Community and service, and Environments.

Each unit comprises a broad question (UbD: Enduring understanding - Results) and a complex summative assessment task (UbD: Results; UbD: Assessment – Evidence). These are shown at the top of the poster for each unit.

There are other activities, such as Eye Dissection or Heat Transfer that contribute to the IBMYP sevenfold assessment regime (bottom left of poster). Their inclusion highlights the non-linearity of the design process, since these are, simultaneously, purposeful activities (UbD Learning experiences) and assessment tasks (UbD Evidence).

Key Ideas (UbD: Results) are shown in two stages: a main idea and particular knowledge and skills. Learning activities within the units include practical activities, theatrical pieces and Internet research.

Units are rounded out, though this is not shown on the poster, by problem sets and self-reflective activities such as mind maps (at start and re-visited during unit), role plays and a focus on attributes of learners: inquirers, thinkers, communicators, organized and collaborative.

References

[1] Wiggins, Grant and Jay McTighe (2006), Understanding by Design, Pearson, NJ, and (2004) Understanding by Design: Professional Development Workbook, Association for Supervision and Curriculum Development, Virginia, U.S.A.

[3] International Baccalaureate Organisation (2008), Middle Years Program MYP: From Principles into Practice, Cardiff, U.K.

[4] Armstrong, Rick, Neil Champion and others (2010), Science for the International Student 4/5: Physics, Nelson Cengage Learning, Melbourne, Unit 1, Light and sight in focus, 1-38, and Unit 6, Transformation by steam, 177-212.

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Students will know . . . (K) • What key knowledge and skills will students acquire as a result of this unit? • What should they eventually be able to do as a result of such knowledge and skill?	*Students will be able to . . .* (S)
Stage 2—Assessment Evidence	
Performance Tasks: (T) • Through what authentic performance tasks will students demonstrate the desired understandings? • By what criteria will performances of understanding be judged?	**Other Evidence:** (OE) • Through what other evidence (e.g., quizzes, tests, academic prompts, observations, homework, journals) will students demonstrate achievement of the desired results? • How will students reflect upon and self-assess their learning?
Stage 3—Learning Plan	
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