Unit Plan

Wave Motion and Geometrical Optics

Ms. Li

IB Phys11/11

**Prior skills and knowledge:**

**BC Prescribed learning outcomes:**

**B1** analyse the behaviour of light and other waves under various conditions, with reference to the properties of waves and using the universal wave equation

**B2** use ray diagrams to analyse situations in which light reflects from plane and curved mirrors

**B3** analyse situations in which light is refracted

**Big Ideas and Skills learned at end of unit**

1. Waves transfer energy via oscillations of particles in the medium. Matter does not transfer.
2. Decouple displacement-position vs. displacement-time graphs and use these to solve problems
3. Pictorially and physically manipulate light. This means being able to position mirrors and lenses to re-direct and focus light.
4. Differentiating virtual and real images by meaning, from calculations, and ray diagrams.
5. Explain the consequences when waves interact with each other and with objects with different penetrance

**IB specific criteria**

4.4 – Wave behavior

- Determine refractive index experimentally

- Qualitatively describe the diffraction pattern formed when plane waves are incident normally on a single-slit

- Quantitatively describe double-slit interference intensity patterns

- Quantitative descriptions of refractive index are limited to light rays passing between two or more transparent media. If more than two media, only parallel interfaces will be considered

C.1 – Introduction to imaging

- Solve problems involving not more than two lenses by constructing scaled ray diagrams

- Solve problems involving not more than two curved mirrors by constructing scaled ray diagrams

- Solve problems involving the thin lens equation, linear magnification and angular magnification

- Explain spherical and chromatic aberrations and describing ways to reduce their effects on images

**Vocabulary:** amplitude, angle of incidence, angle of reflection, centre and radius of curvature, critical angle, diffraction, Doppler shift, focal length, focal point, frequency, image and object distance, incident ray, index of refraction, interference (superposition principle), normal, period, phase, polarization, principal axis, reflected ray, reflection, refraction, total internal reflection, wavelength, wave speed

**Student Development Goals (Ideal student)**

1) Highly motivation to learn, not for marks or grades but for:  
 a) personal interest -> develop interests that matter to them  
 b) natural thirst for knowledge  
 c) applications to real world  
 d) connections made to international/global issues

3) Responsibility over learning and personal development

4) Mastery of skills to do well in the workforce  
 a) collaboration/teamwork  
 b) computing  
 c) leadership  
 d) creativity  
 e) critical thinking

5) Find meaning in their learning through:  
 a) projects  
 b) research

6) Willingness to experiment, taking risks, and challenging themselves

**Assessment**

1. Participation (engagement in classroom activities, class handouts - completion marks and feedback only) - 15%
2. Labs and assignments - 25%
3. Quizzes - 20%
4. Unit Test - 40%

**Materials:** laptop, projector, and quiz/pre-quiz/unit test/problems handouts, Escape room challenge, computer lab

**Extensions:** PhET, Youtube videos, game challenge,

**Cool Videos**

Goldberg light

http://www.wimp.com/goldberglight/

Quantum levitation

https://www.youtube.com/watch?v=Ws6AAhTw7RA&feature=youtube\_gdata\_player

Slinky Drop  
https://www.youtube.com/watch?v=wGIZKETKKdw

**Total lessons:**  14 lessons **Total time: 14hrs 40m**

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| --- | --- | --- | --- | --- |
| Lesson | Activities | Materials and Extensions | Learning Objectives | Assessment |
| 1 | **1) Class intro, social norms/expectations, goal setting**  **2) Inquiry question-**introduction to Waves  -Dark circles in water - vortex, not wave  **3) Nature of waves** -  a) Ask class what they already know about waves. Make sure to cover the 3 types of waves.  b) Can show picture of laser bouncing off mirror vs. cue ball bouncing off pool table and ask students to differentiate the two (idea: matter is not transmitted)  c) Teacher draws diagram of wave on a displacement-time graph for 1 point on the wave and asks students to label as much as they can. They check with a partner to make sure they covered as much as they can. *Trick! They cannot label wavelength because it doesn't give us the physical wavelength of the wave.* Teacher introduces displacement-position and displacement-time graphs.  **4) Video aid with teacher annotation** - help students visualize the 2 different graphs. Make sure students know how to describe the motion of a particle in a wave.  **5) Problem solving**  a) Work with class on problems on displacement-time and displacement-position time graphs. Students review the wave equations  **HMK -**  1) Propose a method to predict how far away is a thunderstorm after seeing lightning and hearing the thunder  2) Derive c = fλ given period and wavelength  3) Problem solving - graphing  4) Bring sunglasses | https://www.youtube.com/watch?v=pnbJEg9r1o8  Optional: do the actual demo | **Prescribed learning outcomes**  **B1** analyse the behaviour of light and other waves under various conditions, with reference to the properties of waves and using the universal wave equation  **Big Ideas**   1. Decouple displacement-position vs. displacement-time graphs and use these to solve problems 2. Waves transfer energy via oscillations of particles in the medium. Matter does not transfer.   **IB specific criteria**  4.2 – Travelling waves  - Sketch and interpret displacement–distance graphs and displacement–time graphs for transverse and longitudinal waves  - Investigate the speed of sound experimentally  - Derive c = fλ  **Skills developed to meet development goals**   1. Critical thinking skills 2. Collaborative skills 3. Asking questions | Inquiry handout  Class sharing of wave properties.  Problem solving session |
| 2 | **1) Mini-demo** - ask students to come to the front with their sunglasses and tilt their head  **2) Discussion of HMK 1 and 2. Check if there's any problem with HMK 3.** - Students will work independently to grasp the problem and think of questions and possible explanations. Students then get into groups of ~3 to try to understand the situation together.  **3) Wave phenomenon** - diffraction, interference, Doppler shift, polarization  Focus on electromagnetic spectrum  *International mindedness: Morse code via radio waves*  a) 3D glasses  b) Ambulance, expansion of universe  c) Quantum extension - video  **Class split - IB students need to pay attention, other students can listen in or do today's homework**  a) Single-slit diffraction  b) Double-slit diffraction  c) Path difference  **HMK:** create 5 questions and choose 1 to write an answer key. See if you can come up with a challenging question (hint: graphing is a good start). | Quantum video on light interference (single/double slit experiment)  Polarizers? | **BIs**   1. Explain the consequences when waves interact with each other and with objects with different penetrance   **PLOs**  **B1** analyse the behaviour of light and other waves under various conditions, with reference to the properties of waves and using the universal wave equation  **IB specific criteria**  4.4 – Wave behavior  - Determine refractive index experimentally  - Qualitatively describe the diffraction pattern formed when plane waves are incident normally on a single-slit  - Quantitatively describe double-slit interference intensity patterns  - Quantitative descriptions of refractive index are limited to light rays passing between two or more transparent media. If more than two media, only parallel interfaces will be considered    **Skills developed to meet development goals**   1. Critical thinking 2. Collaborative skills 3. Asking questions 4. Transfer | HMK responses + collect HMK |
| 3 | **1) Group work -** students form groups of 3-4 and try to solve each other's questions. They revise each other's questions and trade questions with another group. Questions are submitted at the end of class and the next quiz will have at least one question from the class.  **2) Plane mirror -** challenge for students will be drawing ray diagrams with more than 1 plane mirror. Introduce the idea of a virtual image.  **3) Concave mirrors -** applications, labeling the axis, drawing diagrams  **4) Mini-demo with mirrored double bowl**  Quiz next class  HMK - Using what you learned this class, see if you can draw rays that converge to form the virtual image of the object. | Curved mirror double bowl | **BIs**   1. Differentiating virtual and real images by meaning, from calculations, and ray diagrams. 2. Explain the consequences when waves interact with each other and with objects with different penetrance   **PLOs**  **B2** use ray diagrams to analyse situations in which light reflects from plane and curved mirrors  **Skills developed to meet development goals**   1. Critical thinking 2. Asking questions 3. Collaborative skills 4. Self-directed learning 5. Creativity | Questions and solutions designed by students |
| 4 | **1) Check diagrams for HMK** - see what students came up with  **2) Quiz** - at least 1 question is chosen from student responses from the previous day.  **3) Convex mirrors -** applications, labeling the axis, drawing diagrams  **2) Problem - backwards solving** - students get the image produced from the mirror in the problem, they need to find the actual object  **HMK:** Problem set package |  | **Big Ideas and skills**   1. Pictorially and physically manipulate light. This means being able to position mirrors and lenses to re-direct and focus light. 2. Differentiating virtual and real images by meaning, from calculations, and ray diagrams.   **PLOs:**  **B2** use ray diagrams to analyse situations in which light reflects from plane and curved mirrors  **Skills developed to meet development goals**   1. Self-directed learning 2. Critical thinking 3. Collaborative skills 4. Asking questions | Quiz  Problem solving responses |
| 5 | **1) Candle demonstration -**  a) Ask students why, what if, and where do they see this phenomenon.  **2) Law or refraction**  a) Snell's law  b) Critical angle  c) 2 boundary situations?  **3) Concave lenses -** applications, labeling the axis, drawing diagrams, real or virtual image?  **HMK -** most elderly people need reading glasses because the eye has trouble adjusting the curvature of the eye lens to focus light. This is far-sightedness. When we can't see objects far away and need to wear glasses or contact lenses, we're near-sighted. Does concave lenses help us correct for far-sightedness or near-sightedness? Draw a diagram to explain your response. |  | **Big Ideas and skills**   1. Pictorially and physically manipulate light. This means being able to position mirrors and lenses to re-direct and focus light. 2. Differentiating virtual and real images by meaning, from calculations, and ray diagrams.   **PLOs:**  **B3** analyse situations in which light is refracted  **Skills developed to meet development goals**   1. Critical thinking 2. Asking questions 3. Self-directed learning | Questions submitted from class |
| 6 | **1) Go over HMK** **problem**  **2) Convex lenses** - applications, labeling the axis, drawing diagrams, real or virtual image?  **3) Compare and contrast** - Have students work in groups to create a graphic organizer to compare and contrast mirrors and lenses. The groups will get to add their ideas to a collaborative graphical organizer. This could be lead by students.  **3) Questions bank**  a) Students create 1 question individually  b) They form groups of 3-4, they work together to form a question that tries to combine as many of the questions they thought of individually.  c) Groups exchange questions until every group has worked on every other group's questions  Groups submit questions and formulated answers at the end of the class. At least 1 question will be on the quiz. |  | **Big Ideas and skills**   1. Pictorially and physically manipulate light. This means being able to position mirrors and lenses to re-direct and focus light. 2. Differentiating virtual and real images by meaning, from calculations, and ray diagrams.   **PLOs:**  **B3** analyse situations in which light is refracted  **Skills developed to meet development goals**   1. Self-directed learning 2. Critical thinking 3. Collaborative skills 4. Asking questions 5. Creativity 6. Leadership | HMK responses + collect HMK  Class lead graphic organizer  Questions designed |
| 7 | **1) Optics obstacle course** - students work as a class to collect light from 2 flashlights from different parts of the obstacle course and focus them on 2 slits prepositioned to produce the desired diffraction pattern on a whiteboard.  a) Class should break into groups - 1 group working on each obstacle course and 1 group designing and cutting up the diffraction slit to be placed at the 2 predetermined positions.  b) Some students may want to be in charge of determining the focal points of some of the mirrors and lens.  **2) Exit slip**  a) Explain how you would design an experiment to find the focal point of a concave mirror? A convex lens?  Reflection portion:  a) What did you learn from this activity today?  b) What would you, the groups, and the class do differently next time to improve the learning experience?  c) How would you use what you learned today in another situation? | Pre-setup obstacle course in the classroom | **Big Ideas and skills**   1. Pictorially and physically manipulate light. This means being able to position mirrors and lenses to re-direct and focus light. 2. Differentiating virtual and real images by meaning, from calculations, and ray diagrams.   **PLOs:**  **B2** use ray diagrams to analyse situations in which light reflects from plane and curved mirrors  **B3** analyse situations in which light is refracted  **Skills developed to meet development goals**   1. Self-directed learning 2. Critical thinking 3. Collaborative skills 4. Asking questions 5. Creativity 6. Leadership | Exit slip |
| 8 | **1) Quiz**  **2) Class split - IB students need to pay attention, other students can listen in or do today's homework**  a) 2 system lenses/mirrors  b) Aberrations  c) Magnification  **3) IB students devise an experiment** using the following materials to determine the focal length of a concave lens.  HMK - problems package | Experiment: http://stao.ca/VLresources/sci-tie-data/lessons/1400\_1499/DivergingLensExperimentDeta.pdf | **Big Ideas and skills**   1. Pictorially and physically manipulate light. This means being able to position mirrors and lenses to re-direct and focus light. 2. Differentiating virtual and real images by meaning, from calculations, and ray diagrams.   **PLOs:**  **B3** analyse situations in which light is refracted  **IB specific criteria**  C.1 – Introduction to imaging  - Solve problems involving not more than two lenses by constructing scaled ray diagrams  - Solve problems involving not more than two curved mirrors by constructing scaled ray diagrams  - Solve problems involving the thin lens equation, linear magnification and angular magnification  - Explain spherical and chromatic aberrations and describing ways to reduce their effects on images  **Skills developed to meet development goals**   1. Self-directed learning 2. Critical thinking 3. Collaborative skills 4. Asking questions 5. Creativity | Quiz |
| 9 | **1) Inquiry lab**  Given the topics, choose one to work with a partner:  a) How does the temperature affect the refractive index of certain media?  b) How does the changing solute concentration affect refractive index?  c) Make your own animated movie  **(IB option)**  a) Measuring the diameter of a hair with laser  CREATE YOUR OWN EXPERIMENT!  Make sure you have the Materials before you leave today. Make sure you have the Procedure and Data Collection sheet before next class. Pairs can choose to start their lab this class if materials are ready | - Mirrors  - Lens  - Rulers  - Lab write up rubric  ftp://netlib.bell-labs.com/cm/amg/handbook2.pdf | **Skills developed to meet development goals**   1. Self-directed learning 2. Critical thinking 3. Collaborative skills 4. Asking questions 5. Creativity | Student brainstorming of research questions |
| 10 | **1) Inquiry lab**  Students are provided with the materials and they work on their lab.  Pairs hand in their topic, materials, procedures, and show me their data collection sheet. |  | **Skills developed to meet development goals**   1. Self-directed learning 2. Critical thinking 3. Collaborative skills 4. Asking questions 5. Creativity 6. Implementation 7. Hands-on 8. Leadership | Do the students know what they're doing during lab time?  Can go around and ask around. |
| 9 | **Challenge day!**  **1) Escape room** - Class divides students into 3 groups. Any student can choose to opt out. Groups rotate to go inside the room.  Rooms will take less than 20 minutes while the rest of the class works on problems or previous unfinished work. | Escape room | **BC Prescribed learning outcomes:**  **B1** analyse the behaviour of light and other waves under various conditions, with reference to the properties of waves and using the universal wave equation  **B2** use ray diagrams to analyse situations in which light reflects from plane and curved mirrors  **B3** analyse situations in which light is refracted  **Big Ideas and Skills learned at end of unit**   1. Waves transfer energy via oscillations of particles in the medium. Matter does not transfer. 2. Decouple displacement-position vs. displacement-time graphs and use these to solve problems 3. Pictorially and physically manipulate light. This means being able to position mirrors and lenses to re-direct and focus light. 4. Differentiating virtual and real images by meaning, from calculations, and ray diagrams. 5. Explain the consequences when waves interact with each other and with objects with different penetrance   **Skills developed to meet development goals**   1. Critical thinking 2. Collaborative skills 3. Asking questions 4. Creativity 5. Leadership | Progress on Escape room |
| 10 | **Review session**  **1)** **Group work** (groups of 5 students)- students look at all the learning objectives and design 10 questions as a group. Each group chooses the top 5 questions and each student completes a different question. The questions without the answers are passed to another group and they answer the same questions as a group. The questions rotate through the groups as each group attempts the questions. The questions and answers go back to the first group and they assess and give feedback to the responses as a group. The groups get their feedback on their questions and all the questions are handed in at the end of class. *The unit test will have at least 1 question from the questions generated by the class.* |  |  | Questions and responses generated.  Lab write up due |
| 11 | **Unit Test** |  | Students are allowed to bring in a single-sided 8.5" to 11" paper of their own **HANDWRITTEN** notes. Pre-warn the students that writing this piece of paper is not enough to help them do well on this unit test because most questions are concept-based where they must understand and be able to apply the material they learned. | Unit Test |