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**Fall**

**Introduction/Background Information**

Concept Presentation Reflection: Light Refraction

Grade 10 Curriculum

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By definition refraction is a change in the direction of a light beam due to a change in medium. A Dutch mathematician discovered in the 1600s that the ration of the sine of the angles of incidence and refraction was a constant for a given material.

In the equation represents the angle of incidence, is the angle of refraction and is a constant or the index of refraction specific to the mediums involved. The constant depends on the index of refraction, specifically on the ratio of index of refractions of the medium involved. This is called the Snell’s law named after the scientist Snell. A special case of Snell’s law occurs when light leaves a dense medium and enters a less dense medium. As the angle of incidence increases, so does the angle of refraction. But the angle of refraction cannot increase forever; it will reach a maximum value. The angle of incidence which causes the refracted ray to go to 90o is called the critical angle. Any angle of incidence larger than the critical angle will cause the light ray to be totally internally reflected. The critical angle will vary depending on the two mediums involved.

**Advance Preparations/ Teaching Ideas**

Before teaching the concept of refraction, students must be taught about reflection so that they can understand the difference between the two concepts. Students can easily understand any concept if educators can make them think about it. This can be done by organizing a small activity. The materials required for this activity would be a light beam source, an acrylic block and a sheet of paper with a 360o protractor printed on it. The students will point the beam of light at the acrylic block from different angles (10o, 20o, 30o, 40o, and 50 o). They will be required to judge the angle of the beam of light coming out of the acrylic block. Then the question will be asked that why does the angle of the beam of light coming out of the block different from the angle of the beam of light coming in the block?

The above activity will create interest in the students and they will better understand the lessons that will be given to them about refraction. After the lessons, it will be good idea to ask the students to explain some real-life situations using the concept of refraction. The students will be divided into groups containing no more than 4 people. Each group will be given a real-life scenario such as mirages, the sparkle of diamonds, fiber optics, etc. The groups may ask the educator for hints. This activity will allow the students to apply the concept of refraction in real-life scenarios.

Apart from activities, the students must be given a lot of questions involving refraction to make sure that students completely understand Snell’s law. Since students will be using the sine function for the first time, it is really important for the educator to make sure that the students are comfortable with it.

**Curriculum Expectations Addressed (Grade 10: Refraction)**

**E2.1** use appropriate terminology related to light and optics, including, but not limited to: angle of incidence, angle of reflection, angle of refraction, centre of curvature, focal length, luminescence, magnification, principal axis, radius of curvature, and vertex [C]

**E2.3** use an inquiry process to investigate the refraction of light as it passes through a variety of media (e.g., the angles of incidence and refraction as light passes through a clear acrylic block) [PR]

**E2.4** use an inquiry process to investigate the refraction of light as it passes through media of different refractive indices, compile data on their findings, and analyze the data to determine if there is a trend (e.g., the amount by which the angle of refraction changes as the angle of incidence increases varies for media of different refractive indices) [PR, AI, C]

**E2.6** calculate, using the indices of refraction, the velocity of light as it passes through a variety of media, and explain the angles of refraction with reference to the variations in velocity [PR, C]

**E3.4** explain the conditions required for partial reflection/refraction and for total internal reflection in lenses, and describe the reflection/refraction using labeled ray diagrams

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**Lesson Sequencencing**

The following is an outline of how the concept of refraction will be taught:

**Lesson 1: Refraction**  
-What is refraction?

**Lesson 2: Snell’s Law**  
- Explain the calculations involved

**Lesson 3: Critical Angles**

**Lesson 4: Problem Solving**  
-Problems involving Snell’s law

**Potential Student Difficulties and Possible Solutions**

Physics education research has shown that students have difficulties in learning essential optics concepts. Without some familiarity with the properties of light, students are not expected to fully grasp the concept of refraction. A good diagnostic check as a precursor to understanding refraction would be to test the students’ knowledge on reflection.

As with many optical concepts the concept of refraction can be very abstract and difficult for the students to conceptualize. The use of ray diagrams with glass slabs can be difficult for some students, especially with predicting the qualitative characteristics of the rays that are being seen or taught.

The potential student difficulties in understanding refraction could be linked with their common misconceptions about the concept of light like:

* The distance light travels is dependent on its energy.
* That the rays are parallel implies obligatorily that this is the privileged direction; and it is generally a horizontal direction.
* Shadows are formed when light is stopped by objects, but students think that shadows can be conceived as an image, or as something belonging to an object
* Students think that the eyes send out something making it possible for us to see.
* Light always passes straight through transparent material (without changing direction).  
  We can see because light travels to your eyes and then from the eyes to the object.
* Light travels from the eyes to the object.

**Possible solutions to these misconceptions could be:**

* Practice using ray diagrams
* Using ray diagrams for reflection is a method to simplify how light travels and predict its behavior. However, depicting refraction using straight lines (rays) creates a problem. Light is a wave and it is the wave nature of light that is evident in refraction. Hence, students must be reminded that light travels as a wave, not as a ray. Refraction occurs when the light wave changes direction because the angle of incident results in part of the wave hitting the new material first. As one side of the wave is slowed down (if the material is more dense) or sped up (if the material is less dense), the other side of the wave continues at the original speed. Consequently, the wave bends or refracts. Teaching Strategies for this could be:

- Laboratories

- Demonstration using a straw/pencil with water in a glass; but ensure that refraction only occurs between the top surface of the water

- Activity – this activity is outlined in our activity section

* Provide contradictions to students' misconceptions through questions, implications, and demonstrations.
* Encourage discussion, urging students to apply physical concepts in their reasoning.
* Foster the replacement of the misconception with new concepts through (i) questions, (ii) thought experiments, (iii) hypothetical situations with and without the underlying physical law, (iv) experiments or demonstrations designed to test hypotheses.
* Re-evaluate students' understanding by posing conceptual questions

Since students will be using the sine function for the first time in Snell’s law, it is really important for the educator to make sure that the students are comfortable with it. This could be done by providing some practice for sine law.

**Differentiated Instruction**

Within the classroom environment there will be a number of different learners with different needs and abilities to decode information. Recognizing student strengths and weaknesses in these areas will improve student output and concept recognition. Specifically with light refraction, there are a number of DI strategies that can be implemented:

* Students will be given all labs at the beginning of the class to allow more time for review of the work sheets.
* Digital media presentations using power point, videos, blogs, and pictures will be illustrated to supplement verbal teaching for visual/spatial learners.
* Kinesthetic movement activities will be randomized to engage students.
* Extra time will be given for identified students in completion of labs and unit tests.
* Partnering and group collaboration will be encouraged.

**Differentiated Assessment**

Assessment of student’s knowledge will be differentiated based on their Readiness and Preferences. Instructions will be differentiated in terms of ways of learning and ways of demonstrating learning. Students will be involved in a variety of different assessments including diagnostic, formative and summative types. A diagnostic assessment (in the form of a pre-quiz) will be completed prior to instruction so that lessons, which incorporate a variety of learning styles and teach to different background knowledge, can be developed.

**Observational Learning Strategies:**

The teacher’s observations of classroom development and learning can take many forms:

* The reflective pieces can be done in a think-pair-share for students to generate ideas. This will illustrate the ability of each student to contribute to the general group, but also to help promote ideas that may be of the unconventional, or not always thought of.
* Students can be organized into a debate format where they work on their oral communication skills by presenting their argument in front of the class.
* For teachers, formative feedback can be given to the student throughout the unit to not only check for understanding, but to also see if the student has identified the recommended changes, adapted and applied them accordingly.
* The teacher can also identify the amount of materials and research used within the project to aid in the student’s argument.

**Modifications and Accommodations:**

* Students will need to recall prior knowledge in regards to light refraction. Using supplementary worksheets with terms and definitions to be used can be a beneficial resource.
* Digital media presentations using power-point, videos, blogs, and pictures will be illustrated to supplement verbal teaching for visual/spatial learners
* Kinesthetic movement activities will be randomized to engage students.
* Extra time will be given for identified students in completion of labs and unit tests.
* Partnering and group collaboration will be encouraged.

**Applications and Societal Issues/Implications**

The applications of optics range from natural phenomena to technological advances and everyday use. For example, the curriculum expectations require students to describe how visible light is refracted at the interface between two different media (E3.4). Examples of refraction in the real world can be readily identified. Refraction causes many illusions, one of them being the apparent depth of objects submerged in water. Expectation E2.3 requires students to do an investigation on refraction (i.e. Spear-fishing’ Activity). A second natural phenomena caused by refraction is the appearance of mirages. A mirage occurs when refracted light appears as if it were reflected light. Understanding how exactly refraction relates to mirages is beyond the scope of the SNC2P curriculum, but can be used as an extension or hook to make the concepts relevant to things that students are familiar with.

The students will learn how refraction applies to real-life situations such as mirages. They will also learn how scientists are exploiting the concept of refraction in fiber optic cables. Mirages can be taught by showing the students some visuals and talking about instances when the students themselves have witnessed such mirages. Fiber optics can be taught by taking a piece of fiber optic cable and pointing a light beam source towards one end of the cable. The light beam would come out from the other end even though the wire itself is twisted. This will enable the students to understand critical angles more clearly.

Some issues related to optical technologies include social, economical and environmental implications. Social issues related to technologies include effects on our lifestyles, such as sedentary habits, obesity and social isolation (less physical contact). However, technologies such as cell phones, high speed internet (via fiber optics), and satellites have facilitated global social networking and access to information instantly. Some economical considerations are manufacturing and purchasing costs. Many of the new technologies are very expensive and not all individuals have access to them. Lastly, there are many environmental implications due to the development of these technologies. One major concern is the disposal of past technologies as new ones are evolved or invented. Disposal protocols are generally non-existent and recycling technologies need to be further developed. Some of the materials used in these technologies, contain toxic chemicals that are hazardous to the environment and to our health.

**Annotated References**

Bosack, S.V. (2000). Science Is. A source book of fascinating facts, projects and activities. Scholastic Canada Ltd, pg 62-63.

Ontario Ministry of Education (2010). Growing Success: Assessment, Evaluation and Reporting in Ontario Schools, First Edition. Queen’s Printer for Ontario.

Ontario Ministry of Education (2008). The Ontario Curriculum Grades 9-10 Science.

Youth Science Canada. (2011). Smarter Science: Introducing the Framework.

Activity Links

<http://www.ankn.uaf.edu/publications/Alaska_Science/Spear.html>

[http://hyperphysics.phy-astr.gsu.edu/hbase/geoopt/refr.html#c3](http://hyperphysics.phy-astr.gsu.edu/hbase/geoopt/refr.html)