| **Course/Class: Science 9** | **Name:** | **Date:** |
| --- | --- | --- |
| **Topic: Telescopes** | **Unit: E (Space Exploration)** | **Grade: 9** |
| **General/Specific Outcomes (from Program of Studies)**  *[3] (General) Describe and interpret the science of optical and radio telescopes, space probes and remote sensing technologies…(Specific) Explain, in general terms, the operation of optical telescopes, including telescopes that are positioned in space environments.*  **Instructional Outcomes (IOs)**   * *Students will* describe the limitations of refracting telescopes using reflecting telescopes as a comparator * *Students will* compare and contrast the properties and purposes of 2 real telescopes used for astronomy research * *Students will* explain why space telescopes are used for astronomy | | |

| **Time** | **Activities** | **Resources** |
| --- | --- | --- |
| **5 min** | 1. **Hook/Do Now**  * Draw a telescope (images used in Part 2) * **Eyes vs. Telescope**:   + *Show comparative views of objects in the sky; highlight richness*   + *e.g. Jupiter, Andromeda, star clusters*   + *Previous knowledge: emitted/reflected stellar light, Grade 6 Sky Science* | * Slideshow images |
| **15 min** | 1. **(Direct Teaching) What is a telescope, and how does it work?**  * Definition of a telescope * **Optical Refractors (lenses)**   + *Students follow-along: draw basic light-ray diagram of a refractor*   + *example: Binoculars are a pair of two refractors*   + *Limitations of refractors (lens engineering, aberration)* * **Optical Reflectors (mirrors)**   + *Students follow-along: draw basic light-ray diagram of a reflector*   + *example: Reflector designs (Newtonian, Schmidt-Cassegrain, etc)* * **Formative Assessment Q:** Collecting light | * Slideshow images * Whiteboard |
| **10 min** | 1. **(Direct Teaching + Video) Ground and Space Telescopes**  * Light and the Atmosphere (~7 mins)   + *EM spectrum and Earth’s absorption profile*   + *Variety of real telescopes across EM spectrum*   + **Video (together, 3-4 min)**: [Spitzer and NASA’s ‘Great Observatories’](https://www.youtube.com/watch?v=IHS5orsjmTk&ab_channel=NASA) | * [Relevant video](https://www.youtube.com/watch?v=IHS5orsjmTk&ab_channel=NASA) * [NASA website (image: scopes & wavelength)](https://imagine.gsfc.nasa.gov/Images/science/observatories_across_spectrum_labeled_full.jpg) |
| **25 min** | 1. **(Collab. Learning, Partner Activity): Compare/Contrast 2 Real Telescopes**  * Give students the associated handout for this activity; read aloud instructions   + **Part A (10 mins, timed)**: Individual research   + **Part B (15 mins, timed)**: Collaborative Venn diagram | * Attached handout (eLink available for remote/online) |
| **5 min** | 1. **Closer**  * Students hand in the Venn Diagram (from the previous section) * **Exit Ticket**:   + ***Q1.*** *Modern astronomers have largely shifted away from refractor telescopes and instead to reflector telescopes. What is* ***1*** *reason that astronomers might prefer to build and use reflectors instead?*   + ***Q2.*** *What is* ***1*** *reason that space agencies like NASA spend so much money on space telescopes when it is far cheaper and easier to build ground telescopes? (for reference, space telescopes cost 10-30 times as much money to build and maintain).* | * Slide for exit ticket |

**Justification of Lesson Plan & Instructional Methods**

***Student Engagement*** In this lesson, I mixed direct teaching with stimulating, relevant classroom activities to meet instructional outcomes while keeping students engaged. Engagement is initiated with a quick and fun Do Now which is then used soon thereafter to emphasise and rectify a misconception. Having students engage other learning modalities (e.g. tactile/visual) encourages a diverse range of students to interact with the material.

Next, we look at views of Jupiter which can be seen by students in *tonight’s night sky*, giving the content relevance as something observable in the students’ own lives (extending learning beyond the classroom). Finally, the direct teaching section is capped by a fun and motivating animation before students are paired for a collaborative activity that allows them choice and freedom to select aspects of what they’d like to study. Together, this all ensures a dynamic 60 minutes with a variety of learning modes while still establishing a consistent and clear content narrative throughout.

***Digital Learning Tools*** I chose to use an animated video from NASA to transition from direct teaching to the paired/collaborative activity. The video’s content is efficient for how short it is (3.5 mins), and serves as a natural content conduit between the short section on atmospheric absorption and the activity. Its light and playful feel softens the locus switch from teacher-centered to student-centered learning, while simultaneously grasping and holding onto attention extremely well. Finally, the animation primes students to *want* to select a telescope and learn about it for the next activity. NASA has already spent significant resources developing wonderful visual animations - why reinvent the wheel? By taking advantage of established, expert resources and placing them productively into the lesson enables both teachers and students to get the most out of these expert institutions.

***Student Misconceptions*** Though the lesson was not built primarily to dissolve a misconception (rather, to introduce more specific, novel content) one misconception is addressed herein. This occurs during the initial direct instruction section and is tied to the Do Now. Most people think telescopes are more or less of one variety (small refractors), or at the very least small amateur telescopes. On the other hand, a telescope is defined in a much broader sense and allows quite different looking instruments to still act as a telescope (e.g. a radio dish). When students are asked to produce their images from the Do Now, the assumption is that most will draw small amateur refractors (e.g. thin body, eyepiece on the end) and the teacher can segue off of this into the broader view of what really defines a telescope.

If I was teaching this unit, the *next* lesson day would likely explore misconceptions related to telescope parameters - such as longer telescopes are “better” telescopes, that a bigger aperture is always better, and that refractors use only lenses and reflectors only use mirrors (some refractors use a mirror to redirect the eyepiece light, and all reflectors use a lens in the eyepiece!)

[Word Count: 496]