PowerPoint Notes on Optics Basics

Note: This is a very long Power Point lesson, including details appropriate for both physics and astronomy courses. I have included all the slides in the original file and printed versions, but I have also created Physics and Astronomy versions of the file that are available on the MIT Haystack website (http://www.haystack.mit.edu/edu/pcr/resources/lessonplans.html) and may be better suited to some courses than the complete (61 slide) version. The Physics version is still quite long, but the astronomy one is significantly shorter, as most astronomy courses do not go through the details of ray diagrams and the mirror and lens equations.

Slide 1

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Slide 4

This photo shows a conjunction of the moon, Venus, and Jupiter over Los Angeles in 2008. The apparent brightness of the objects in this image should help students understand the difference between inherent luminosity and apparent intensity. The city appears brighter than the moon, which appears bright than Jupiter (higher, dimmer, to the right) and Venus (lower, brighter, to the left). In fact, Jupiter gives off much more light than any of the other objects, but because of its great distance, appears dimmer.

Slide 5

Because glass is partially reflective, some of the light that encounters a pane of glass reflects off of that pane. When there is a lot of light coming from outside a window, that light is much brighter than the reflected light. But, at night, when the outside light is minimal, the reflected light becomes visible, and the glass panes act like mirrors.

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Slide 9

Very large radio telescopes occasionally have problems involving the differential temperature between the top and bottom of their dish, especially when the dish is in a near-vertical position, as when it is observing objects at low altitudes.

Slide 10

Direct TV is reflective to Radio Waves; the wave in the image of the shuttle is reflective to visible light, and the James Clerk Maxwell microwave telescope is reflective to microwaves. The JCMT is located on Mauna Kea and is operated by Canada, the UK, and the Netherlands. (The atmosphere is only marginally transparent to microwaves, so any observations done from Earth are best done at as high an elevation as possible to avoid as much microwave-absorbing atmosphere as possible.)

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It might be useful here to calculate the wavelength of the radio wave, then compute the 1/20 standard of irregularities.
Wavelength = 2.71 cm, so irregularities need to be smaller than 1.35 mm.

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Because radio has a long wavelength, the resolution of radio sources (proportional to diameter, inversely proportional to wavelength) is quite poor. Thus, to counteract the long wavelength, the dish is (very, very) large. However, the dish does not need to be smooth on an optical scale, given the long radio wavelengths.

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Slides 18 & 19

Each ray follows the law of reflection (angle of incidence = angle of reflection), but these are shortcuts, which can be used to make ray diagrams.

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Slide 21

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Slide 26

It might be useful to have students identify the type of image shown in each example, as well as the type of mirror used to produce it. The Bean is a convex mirror, producing virtual, upright, smaller images. The James Webb Space Telescope uses concave mirrors, producing real, inverted, smaller images. The side view mirror in cars is convex, producing images that are smaller, virtual, and upright. Because they are smaller, they are "closer than they appear." A magnifying mirror is a concave mirror and produces virtual, upright, larger images (when the observer is closer to it, as in the image). Rearview mirrors are flat mirrors, producing virtual, upright, same size images. Security mirrors are convex and produce virtual, upright, smaller images.

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Slide 29

If your students are interested, there is a great virtual tour including lots of history and background information at http://astro.uchicago.edu/vtour/.

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Slide 32

Green Bank Radio Telescope (the Robert C. Byrd Green Bank Radio Telescope, formally) is a 100 meter offset reflector.

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The dish appears to be pointed downward, but is actually aimed at 8° above the horizon. In the picture on the bottom right, when the line of sight of the camera is aligned with the received, the blue sky is visible in the reflector at the middle of the dish.

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Slide 40

http://www.haverford.edu/physics/songs/snell.htm links to the Snell song.

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Slide 43

These are examples of total internal reflection. On the left, students may be reminded of the familiar experience of noticing that the surface of water often acts as a mirror when viewed from underwater. On the right, a fiber optic cable is shown with light being transmitted through it. Fiber optics are an application of total internal reflection, as the signal can be transmitted through the medium with essentially no losses as long as the light never encounters the edge of the fiber at an angle less than the critical angle.

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Slide 45

Slide 46

Slides 47 & 48

Each ray follows Snell's Law, but these are shortcuts that can be used to make ray diagrams.

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Slide 53

It might be useful to ask student to identify the type(s) of lenses in each application, as well as the type of image produced. The magnifying glass in the picture is producing a virtual, upright, enlarged image from a convex lens. Many glasses and contacts that students use are concave lenses (these are no exception), producing a virtual, upright, reduced image. The projectors both produce real, inverted, larger images, although students may wonder why the image does not appear inverted (the object is flipped before being projected). The Yerkes Observatory (run by the University of Chicago) is a 40 inch refractor, which is the largest refracting telescope in the world. An astronomer, Dr. Kyle McCabe Cudworth, is standing beside the telescope for scale.

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Slide 60

If teachers or students are interested, there is a great virtual tour including lots of history and background information at http://astro.uchicago.edu/vtour/.

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