SC16: Build a Telescope: Explore the EM Spectrum and the Universe

Short Course - Saturday, October 20, 2012
Coral Clark, Pamela Harman, Dana Backman
SOFIA / USRA / SETI Institute / NASA-Ames
Agenda

• Introductions
• KWL
• Optics and telescopes: Lens PLay
• (Break)
• Galileoscope: Build Yours!
• (Break)
• The EM Spetrum and Exploring the Universe
• Resources
• KWL and Wrap up
<table>
<thead>
<tr>
<th>Know</th>
<th>Want to Know</th>
<th>Learn</th>
</tr>
</thead>
</table>
| Collects light [to a detector, like an eye)  
Diameter is important  
There are some with reflectors/lenses/or both  
Tool to observe distant objects (brings objects closer) | How to improve the clarity/resolution?  
How to teach optics to students?  
What to look for in a beginner telescope?  
What to look for in the night sky? | Diameter improves clarity – clean optics help  
Telescope needs to be same temperature as environment  
Whole curriculum – Teaching with Telescopes with large array of activities and lessons  
You get what you pay for with telescopes – often best to start with binoculars  
Go for diameter, not magnification  
Reflecting telescopes less expensive  
At Galileoscopes.com, there is book of what to look for... updated each year.  
Sky and telescope also a good reference.  
Edmund Scientific publishes |
Single Converging Lens

Up close to an object, a converging lens forms a magnified, right-side-up image.
Single Converging Lens

As the lens is moved away from the object, a point is reached where the image “explodes.”
Single Converging Lens

As the lens is moved even farther from the object, the image becomes inverted and smaller.
Images of distant objects may be focused onto a surface when the lens is at the right distance from the surface.
The projected image is inverted, reduced, and “real”—formed where the actual rays of light are focused.
Bringing Light to a Focus

You can explore the way a lens focuses light by letting the light graze the surface of a piece of paper.
The distance from the lens to the point where light comes to a focus (the “focal point”) is the “focal length” of the lens.
Measuring Focal Length

Find the distance between lens and paper where the image of a distant object comes into focus.
Measuring Focal Length

Use a ruler to measure the focal length of the lens. Do this for all of your lenses....
The main light collecting lens is the “objective”. Add a second lens—the “eyepiece”—held close to your eye. The eyepiece works in “magnifying mode” to magnify the image formed by the objective.
Objective and Eyepiece

Depending on the focal length of the eyepiece, the resulting “telescopic” image will achieve different magnifications. Remember, you’re simply holding a magnifying glass up to the image formed by the objective....
Calculating the Magnification

\[ M = \frac{F_o}{F_e} \]

Fe (focal length of eyepiece)  Fo (focal length of objective)
Light Gathering Power

- Light Gathering Area (LGA) = \(3.14 \times (D / 2)^2\)

- Light Gathering Power (LGP) of a telescope = \(\frac{LGA_{\text{telescope}}}{LGA_{\text{human pupil}}}\)

LGP simple formula = \((\text{diameter of telescope aperture})^2 / (\text{diameter of human pupil})^2\)
Resolution

Can you see the ears?
Can you see the eyes?
Resolution

Can you see the whites of the eyes?
**Resolution**

Resolution is the minimum angle over which a telescope (or an eyeball) can distinguish a pair of adjacent objects (stars, leaves in trees, facial features) as distinct and separate image details.

\[ R = \frac{116}{D} \]

- \( R \) is in seconds of arc, \( D \) is the diameter of the objective in millimeters
- *(this is an approximation for Dawes Limit for yellow light, at 550 nm wavelength)*