

Designing a Telescope

Mr. Indigo is a multi-billionaire who is looking to invest part of his vast fortune in space exploration. His plan is to fund the construction of the world's most powerful and useful telescope so that we can learn more about the universe than ever before. Mr. Indigo is hoping that scientists will discover that no intelligent life exists anywhere in the universe so that people here on Earth will finally appreciate how precious life is and stop fighting with each other. Mr. Indigo's ultimate goal is to save the Earth but he would also like to have some fun, learn about the universe, and make more money while he is doing this.

Your job is to work with your team to design a telescope that will impress Mr. Indigo so much that he will give you the money to construct the telescope and also make you rich! Your budget is 10 billion dollars, but obviously Mr. Indigo does not want to waste his money on a foolish idea. Answer the following questions on a separate piece of paper as you design your telescope. Use complete sentences, but do not write out the questions. Lastly, draw a basic blueprint of your telescope and present your idea to Mr. Indigo and the other design teams.

- 1. List the names of the people on your design team. Your design team size can be 1, 2, or 3 people.**
- 2. How powerful will your telescope be?** In other words, how far from Earth will you be able to see to and how detailed will the images be? The size of the universe is roughly 13.7 billion light-years across so the light from the most distant objects takes 13.7 billion years to reach us. The greater the power, the greater the telescope size and the greater the construction cost. Assume that 1-meter objective will cost 1 million dollars and that a 1-meter telescope will be able to see things that are 1 billion light-years away, a 2-meter objective will cost 2 million dollars and that a 2-meter telescope will be able to see things that are 2 billion light-years away, and so on.
- 3. Where will your telescope be located: on Earth, in orbit around Earth, or on the Moon? Describe the precise location and explain why you have chosen such a location.** The cost for building an observatory on a high mountain of Earth is roughly 10 million dollars (100 times cheaper than an orbiting space telescope and roughly 1000 times cheaper than building one on the Moon). In addition, an earthbound telescope found at sea level costs roughly one-quarter as much as an earthbound telescope found on top of a mountain. Mountain tops on Earth have thinner air which aids in viewing stars. Desert areas on Earth have darker and clearer night skies because there is less moisture in the air. Areas that are far from cities have darker skies because there are no city lights to reflect off the sky at night.
- 4. Which kinds of electromagnetic radiation will your telescope be designed to see and why are these forms of electromagnetic radiation important to astronomy?** Remember that only radio waves and visible light can reliably make it through Earth's atmosphere and reach sea level. Microwaves and infrared radiation can usually reach the tops of high mountains, but ultraviolet, x-rays, and gamma rays are mostly blocked by our atmosphere. All forms of light can be easily viewed in space or on the moon. If your telescope will be designed to capture visible light, will it be a reflecting or refracting telescope?
- 5. Will people operate your telescope or will it be run by a computer?** If run by people, do they need to be with the telescope during its operation or can they control it remotely from afar? If run by a computer, what will the objectives of the computer be? Computers usually cost a lot less than people but they do occasionally fail which could be expensive and difficult to fix if the computer is located in a remote area such as on a mountain top or on the moon. Traveling to a telescope that is located on a mountain, in space, or on the moon would be expensive and dangerous. Assume that an astronomer will cost \$95,000 per year and a computer will cost \$20,000 per year.
- 6. What kinds of supplies, facilities, and equipment will your telescope observatory need?** Will you need air conditioning or even an air supply? Will you need bathrooms, kitchens, and sleeping quarters? Humans can only breathe at altitudes less than 24000 feet so supplemental oxygen would be needed on top of the world's highest mountains. Even if your observatory is run by computers, you will need air conditioning to keep the computers operating. How will you get people and supplies to your telescope? Assume that each astronomer working at your observatory will make \$95,000 per year and that support personnel, such as custodians, cooks, etc. will make \$50,000/year.
- 7. What special kinds of technology will you incorporate into your design?** You can add whatever you want to your observatory, such as satellite TV, but remember that these additions will cost additional money. It is recommended that you add only items that astronomers and Mr. Indigo will benefit from. Estimate a cost for these items.
- 8. What materials will your telescope be constructed out of?** Recycled materials are generally more expensive than new materials. Transporting materials to the moon would be very expensive, but some materials, such as iron and even water, could be mined on the moon. An orbiting telescope would either need to be small enough to build on Earth and then transport into space (i.e., no bigger than a school bus), or it would need to be constructed in the microgravity of Earth-orbit which would be extremely dangerous, difficult, time-consuming, and expensive to accomplish.
- 9. How will you power your telescope?** Remember that solar power only works when there is sunlight and *optical* telescopes only work at night because of the glare of the sun. Wind power only works where there is an atmosphere. It would be extremely expensive to run electrical wires up a high mountain and impossible to run wires into space or to the moon.
- 10. How long will it take to build your telescope and what shortcuts could you take to speed up construction?** A basic mountain top telescope takes about 8 years to complete while sea level telescopes can be built in only about 3 years. Orbiting telescopes take about 15 years to build and moon telescope would take roughly 35 years to build because of all the specialized equipment that would be needed. The more powerful the telescope, the more expensive it is to make. Remember, time is money so the longer the project takes to complete, the lower the profits.
- 11. How will your telescope make Mr. Indigo money?** One way for a telescope observatory to make money would be to bring tourists in to visit the observatory. Of course, this is only feasible on Earth and would require hotel accommodations, gift shops, and tours, all of which cost a lot of money to operate. Another way to make money would be to use the telescope to make a discovery that creates new technology that can be sold for top dollar. Of course, there is no guarantee that such a discovery could be made. The observatory could also be rented to other scientists that are willing to pay to use your telescope, but that would limit the time you can spend using the telescope. What ideas can you come up with to make money with your telescope? Estimate your earnings.