Calculating Magnification, Field of View, Light Gathering Power, and Optical Resolution in a Telescope

There are four basic optical characteristics governing a telescope which effect observing:

- **Magnification** (or Magnifying Power)**:** A telescope's image enlargement capability.
- **Field of View (Actual):** The area of the sky viewed with a telescope-eyepiece combination.
- **Light Gathering Power:** The amount of light a telescope brings to the eyepiece.
- **Resolution** (or Resolving Power)**:** The degree of clarity, or definition, a telescope can discern.

Magnification – (Magnifying Power - Measured as **x**, or Times)

The magnification of any telescope is changed by using different Focal Length eyepieces. The Magnification (**M**) is given by the following formula:

$$M = F \div f \qquad \text{(i.e. F divided by f)}$$

Where: **F** = Focal Length of the Telescope; and
f = Focal Length of the eyepiece being used.

For example: If the Focal Length of the telescope is 1500mm, and the eyepiece Focal Length is 20mm, then the Magnification is: **M = F ÷ f = 1500 ÷ 20 = 75x**

Actual Field of View – (Measured in Degrees, °)

With respect to "Field of View", two fundamental eyepiece specifications are Focal Length in millimeters, and the Apparent Field of View in degrees, of the eyepiece. (Eyepiece manufacturers only state the Apparent Field of View because the Actual Field of View depends on the telescope-eyepiece combination.) The formula to determine the Actual Field of View of an eyepiece in a given telescope is:

Actual Field of View (in degrees) = Apparent Field of View (in degrees) ÷ Magnification

From the example above: If the eyepiece has an Apparent Field of View of 30° (and since we already know its magnification is 75x), then the

Actual Field of View = Apparent Field of View ÷ Magnification = 30° ÷ 75 = 0.4°

Light Gathering Power – (LGP: Measured as Times)

The Light Gathering Power of a telescope is the amount of light that is delivered to the eyepiece by the telescope's Primary Objective (mirror or lens). It is a function of the area of the Primary Objective. Hence, if we compare two telescopes for LGP, one with a 6 inch diameter objective, and one with a 3 inch diameter objective, the 6 inch telescope will collect four times as much light as the 3 inch telescope. i.e. $6^2 \div 3^2 = 4$.

Telescope Resolution – (Resolving Power Θ: Measured in Seconds of Arc, **"**)

The Resolution (Resolving Power) is a telescopes ability to discern two point light sources (such as stars) that are very close together. This capability is determined by the diameter of the telescope's Primary Objective (lens or mirror.) It is defined by $\Theta = 4.56 \div D$, where Θ is the angular separation of the two stars in Seconds of Arc, where one second of arc = [1/3600]°) and D is the Objective diameter measured in inches. However, due to the Earth's atmosphere, the limiting resolution for all telescopes, 6 inches or larger, is about 1**"**. Even the largest ground based telescopes are restricted by the conditions of the atmosphere.

NOTE: Maximum Usable Resolution Rule of Thumb: Some telescopes (those usually found in department stores) having small diameter objective lenses, or mirrors, may claim Magnifications of up to 600x. However, the magnification you can actually use will often be much less due to the telescopes' Resolution. The Rule of Thumb for Maximum Usable Magnification is 50x for each inch of objective. i.e. A telescope with a 50mm (2 inch) objective lens will have a Maximum Usable Magnification of about 100x.