Homework #4

1. a). The magnification $m = \frac{f_1}{f_2} = 40/1 = 40$.

b). $D = 10inch = 25.4cm = 0.254m$. Pick a typical visible light wavelength $600nm = 0.6\mu m$ to evaluate the resolution. $\Delta\theta = 0.25\frac{\lambda}{D} = 0.25*0.6/0.254 = 0.59arc\ sec$.

c). The diameter of the pupil changes according to the brightness level of the enviroment, on the scale of a few mm. Let's take it as $d = 5mm$, and $D = 254mm$. The light gathering power $P\propto D^2$, so the telescope is $\frac{D^2}{d^2} = \frac{254^2}{5^2}\approx 2580$ times powerful than human's eyes on collecting photons.

d). The lens of refracting telescope is harder to make than the mirror of reflecting telescopes. The material (glass) usually is special and expensive. Lenses have two sides which need to be carefully machined and polished. Sometimes, several lenses have to be glued together to achieve desired optical properties. Its size can't be very big, otherwise the lens will deform. Reflecting mirrors can be made from metal and be supported from the back. We only need to grind and polish one side of the mirror. The supporting structure on the back of the mirror will not cause much problem to the performance of the telescope.

e). The construction of the smaller refractor is usually compact and straight forward. It doesn't have a secondary to block some light. Center occultation caused by the reflector secondary may cause worse diffraction pattern, so make stars's images fuzzier. Some planet observors claim that the chromatic aberration caused by the refractor lens actually make planets prettier.

2. a). $f = \frac{speed\ of\ light}{wavelength} = \frac{3\times 10^{10} cm\cdot sec^{-1}}{3cm} = 10^{10} Hz = 10GHz$

b). $\Delta f = \frac{v}{c+v}\times f_0 = \frac{35}{35+3\times 10^5\times 3600/1.609}\times 10^{10}\approx 521Hz$, if you were driving towards the policeman. Otherwise $\Delta f\approx -521Hz$.

c). Replacing 35 with 1 in b), you will find $\Delta f = 14.9Hz$, the fractional uncertainty is $14.9/10^{10} = 1.49\times 10^{-9}$.

3. Each photon has energy $E = h\nu = (6.63\times 10^{-34})\times(100\times 10^6) = 6.63\times 10^{-26}\ J$.

The radio station has a power $10^5\ J{\cdot}s^{-1}$, it is equivalent to $\frac{10^5}{6.63\times10^{-26}}\approx1.5\times10^{30}$ *photons per sec.*