Please answer the following questions and give a brief explanation of your answer.

1. A collimated red laser beam crosses a 1mm × 1mm square aperture. The pattern generated behind the aperture is observed on a screen at the following distances $d$: i) 1cm, ii) 10cm, iii) 10m, and iv) 100m.

   a. All the patterns look exactly the same. T F
   
   b. The pairs (i) - (ii) and (iii) - (iv) look the same. T F
   
   c. Is there any real physical difference between patterns (iii) and (iv)?
   
   d. We want to record the pattern (iv) on a 1cm × 1cm CCD camera. Is it possible? If yes explain how, if not explain why and propose at a solution.
   
   e. We now decrease the intensity of the laser to a very low level, take out the screen and watch directly with the naked eye placed on the axis normal to the aperture at distance 10m (do not try this in real life). What do we see? Explain.

2. A monochromatic point source of a scalar perturbation of frequency $\nu$ is located at the origin of coordinates. Provide a mathematical description of the perturbation at distances $1\mu m$, $10cm$, $10^4 m$. What is the complex amplitude of the wave at 1m? Briefly justify any approximations you find appropriate to consider.

3. We want to build a spectrometer to resolve two lines at 538nm and 542nm in the first diffraction order. We can choose among four gratings:
   
   a. Sinusoidal amplitude grating, period $T=10\mu m$, width $2w=2mm$
   
   b. Sinusoidal phase grating, period $T=10\mu m$, width $2w=1mm$
   
   c. Sinusoidal phase grating, period $T=20\mu m$, width $2w=2mm$
   
   d. Sawtooth phase grating, period $T=5\mu m$, width $2w=0.5mm$

Which one would you choose and why?