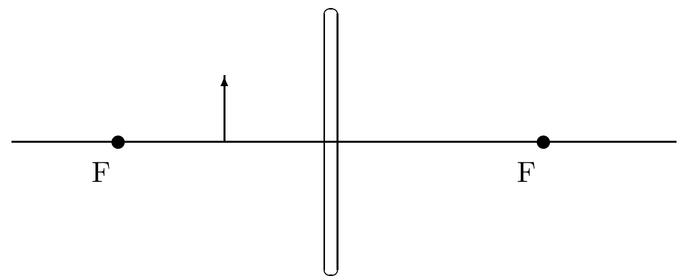
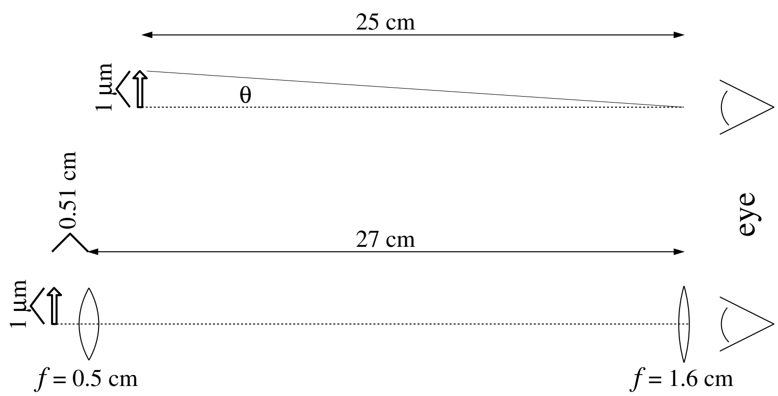
Answer **five** of the following six problems

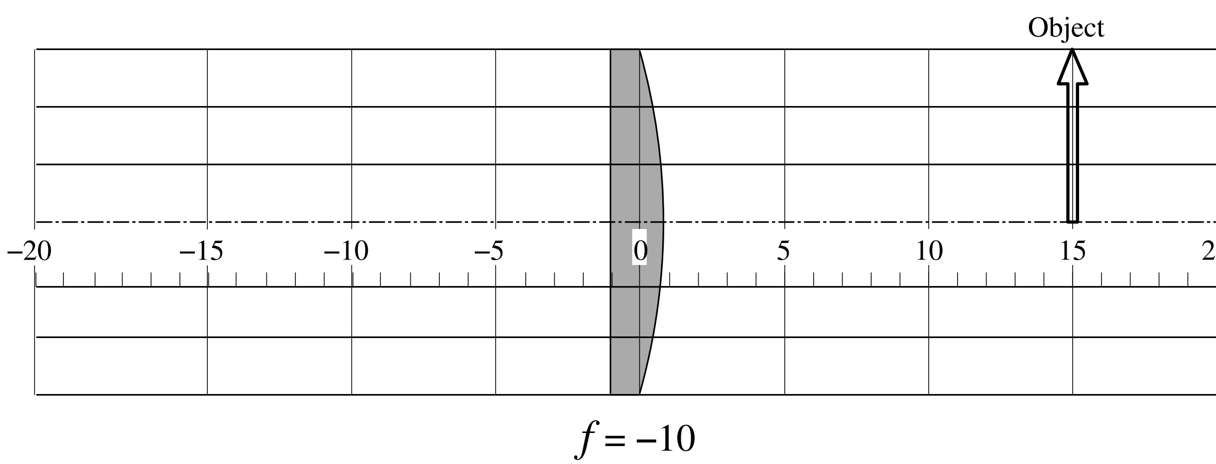
1. Draw a ray diagram for a converging (convex) lens with the object located as shown at $p = |f|/2$. Describe the image:
   Is it Real or Virtual?
   Upright or Inverted?
   What is the magnification?
   Draw in an eye (as in, for example, the below diagram) that could see the image.



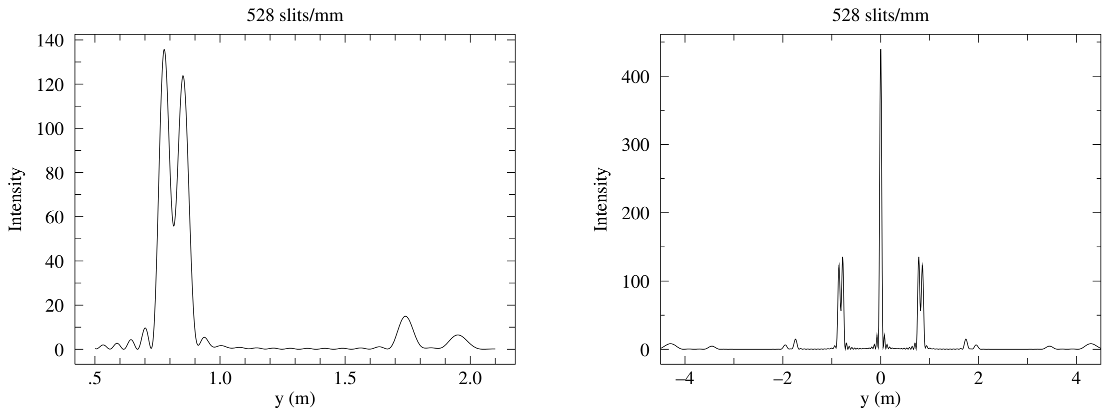
2. A 1 μm high object is 0.51 cm to the left of a converging lens with focal length 0.50 cm. A converging lens with focal length 1.6 cm is 27 cm to the right of the first lens and directly adjacent to the viewing eye. Where is the image? What is the magnification? Is the image virtual? Upright? As viewed by an unaided eye 25 cm from the object (i.e., the typical near-point), what angle θ would the object subtend? What angle does the image subtend as viewed through the lenses? What is the angular magnification?



3. An object sits 15 units from a $f = -10$ unit mirror. Directly on the below diagram, accurately draw (using a ruler) the four principal rays and use those rays to locate the image. Draw in the image as determined by the rays. Use the usual convention: solid lines for real rays and dotted lines for extrapolated rays. Calculate the location and magnification of the image. Compare the ray-based image size and location to your calculated values.



4. A beam of light, consisting of a mixture of two wavelengths, is normally incident on a diffraction grating with 528 slits/mm. The light intensity on a screen $D = 3$ m from the slit is plotted below as a function of the distance, y, along the screen with origin at the bright central maximum. The plot on the left is an expanded-scale version of a portion of the plot on the right. (A) Directly on the below right plot, label each peak pair with its corresponding order m. Directly on the below right plot, indicate the location of the first order single-slit diffraction minimum. (The graphs are a bit ambiguous, so please carefully report the **basis** for your estimate, perhaps by sketching in your estimated envelope which is the single-slit diffraction pattern.) (B) Using the second order maximums, calculate the two wavelengths in the incident light. (C) Using your results from (B) calculate the y location of the third order maximums. Are there peaks near your calculated positions?



5. Light from a sodium lamp ($\lambda = 589$ nm) is sent into a Michelson interferometer; light travelling on the two arms is combined on a screen forming the usual multi-ring interference pattern. When a thin slice of muscovite mica (thickness: 20 μm) is put into one arm of the interferometer, there is a shift of 20 fringes. What is the index of refraction of the mica?

6. A wire loop supports a soapy water film in air; a beam of normally incident light illuminates the film.

   (a) As the light enters the film (i.e., at the air-film interface), is the reflected light in phase with the incident light?

   (b) As the light exits the film (i.e., at the film-air interface), is the reflected light in phase with the incident light?

   (c) Compare the amplitude of the reflected light is the above cases (a) and (b).

   (d) If the films seems to strongly reflect light of wavelength 400 nm (in air), how thick is the film?

Physical Constants:

speed of light $= c = 2.9979 \times 10^8$ m/s
permittivity $= \varepsilon_0 = 8.8542 \times 10^{-12}\ \mathrm{C^2/(N \cdot m^2)}$
permeability $= \mu_0 = 4\pi \times 10^{-7}\ \mathrm{T \cdot m/A} = 1.2566 \times 10^{-6}\ \mathrm{N/A^2}$
index of refraction of water $= 1.33$
index of refraction of glass $= 1.50$