Part VI

Part A

1. d (the eye is only sensitive to a small range of frequencies within the electromagnetic radiation spectrum)

2. a (the difference in length is an integer-multiple of the wavelength)

3. c (each wavelength produces a dot in a different place)

4. c (the diverging lens diverges the rays, leading to an image on the same side of the lens as the object yet closer to the lens than the object)

5. a (when the object is closer than the focal length, the image is virtual, farther away and larger; when the object is at the focal length, the image is infinitely far away)

6. d (the ratio of object height to object distance is the same as the ratio of image height to image distance)

7. e (diverging lenses create virtual images on the same side of the lens as the object but closer than the object; consequently, the image is upright and smaller than the object)

8. Shine the laser through each grating. The grating that produces dots that are farther apart will be the grating with the slits/scratches closer together.

Part B

1. The first task is to identify the critical angle, i.e., the minimum angle of incidence that will result in total internal reflection. At this angle, the angle of refraction is 90°. From Snell's law, we have

$$n_{\text{glass}} \sin \theta_i = n_{\text{air}} \sin(90^\circ)$$

   where the left-hand side (incident ray) corresponds to the ray in the glass and the right-hand side (refracted ray) corresponds to the ray in the air. Since $n_{\text{air}} = 1$ and $n_{\text{glass}} = 1.523$, we can solve for θ_i to get 41°.

At location A, the beam hits the edge with an incident angle of 60°. This is more than 41°and so the beam reflects totally. By geometry, one can show that the angle of incidence at B is 30°. This is less than 41°and so the beam only partially reflects. The answer is B.

2. (a) The magnification is equal to $-d_i/d_o$ (see equation 20.1). Since, in this case, the image distance equals the object distance, the magnification must be 1. Since the image and object are not at the same place, the image must be a real image (positive image distance) and so the answer must be -1.

   (b) Since the $d_i = d_o$ and $d_i + d_o = 80$ cm, this means that $d_i = d_o = 40$ cm. Plugging in to the thin lens equation, we get

$$\begin{aligned} 1/f &= 1/(40 \text{ cm}) + 1/(40 \text{ cm}) \\ &= 2/(40 \text{ cm}) \\ &= 1/(20 \text{ cm}) \end{aligned}$$

   or $f = 20$ cm.