3. The amount of light focused on the film by a camera is proportional to the area of the aperture through which the light enters the camera. Since the area of a circular opening varies as the square of the diameter of the opening, the light reaching the film is proportional to the square of the diameter of the aperture. Thus, increasing this diameter by a factor of 3 increases the amount of light by a factor of 9, and (c) is the correct choice.

4. When the eye is shorter than normal, the lens-cornea system fails to bring light from near objects to a focus by the time it reaches the retina, resulting in a blurry image. Light rays entering the pupil from distant objects are less divergent than those from near objects, and the lens-cornea system can focus them on the retina. Such an eye is farsighted, or has hyperopia, and needs a converging corrective lens to help bring rays from near objects to focus sooner. The correct choice is (c).

5. When the eye is longer than normal, the lens-cornea system will bring light from distant objects to focus before it reaches the retina. Rays from near objects are more divergent and the lens-cornea system brings them to focus farther from the lens, on the retina. This means that the eye can see near objects clearly, but is unable to focus on distant objects. Such an eye is nearsighted (myopia), and needs a diverging corrective lens to make the rays from distant objects more divergent before they enter the eye. Choice (b) is the correct answer.

6. The aperture of a camera is a close approximation to the iris of the eye. The retina of the eye corresponds to the film of the camera, and a close approximation to the cornea of the eye is the lens of the camera.

10. Under low ambient light conditions, a photoflash unit is used to insure that light entering the camera lens will deliver sufficient energy for a proper exposure to each area of the film. Thus, the most important criterion is the additional energy per unit area (product of intensity and the duration of the flash, assuming this duration is less than the shutter speed) provided by the flash unit.

25.1 The f-number (or focal ratio) of a lens is defined to be the ratio of focal length of the lens to its diameter. Therefore, the f-number of the given lens is

$$f\text{-number} = \frac{f}{D} = \frac{28\text{ cm}}{4.0\text{ cm}} = \boxed{7.0}$$

25.2 If a camera has a lens with focal length of 55 mm and can operate at f-numbers that range from $f/1.2$ to $f/22$, the aperture diameters for the camera must range from

$$D_{\text{min}} = \frac{f}{(f\text{-number})_{\text{max}}} = \frac{55\text{ mm}}{22} = \boxed{2.5\text{ mm}}$$

to

$$D_{\text{max}} = \frac{f}{(f\text{-number})_{\text{min}}} = \frac{55\text{ mm}}{1.2} = \boxed{46\text{ mm}}$$

25.5 The exposure time is being reduced by a factor of

$$\frac{t_2}{t_1} = \frac{1/256\ \text{s}}{1/32\ \text{s}} = \frac{1}{8}$$

Thus, to maintain correct exposure, the intensity of the light reaching the film should be increased by a factor of 8. This is done by increasing the area of the aperture by a factor of 8, so in terms of the diameter, $\pi D_2^2/4 = 8\left(\pi D_1^2/4\right)$ or $D_2 = \sqrt{8}\, D_1$.

The new *f*-number will be

$$(f\text{-number})_2 = \frac{f}{D_2} = \frac{f}{\sqrt{8}\, D_1} = \frac{(f\text{-number})_1}{\sqrt{8}} = \frac{4.0}{\sqrt{8}} = 1.4 \text{ or } \boxed{f/1.4}$$

25.9 The corrective lens must form an upright, virtual image at the near point of the eye (i.e., $q = -60.0$ cm in this case) for objects located 25.0 cm in front of the eye ($p = +25.0$ cm). From the thin lens equation, $1/p + 1/q = 1/f$, the required focal length of the corrective lens is

$$f = \frac{pq}{p+q} = \frac{(25.0\text{ cm})(-60.0\text{ cm})}{25.0\text{ cm} - 60.0\text{ cm}} = \boxed{+42.9\text{ cm}}$$

and the power (in diopters) of this lens will be

$$\mathcal{P} = \frac{1}{f_{\text{in meters}}} = \frac{1}{+0.429\text{ m}} = \boxed{+2.33\text{ diopters}}$$

25.13 (a) The lens should form an upright, virtual image at the far point $(q = -50.0\text{ cm})$ for very distant objects $(p \approx \infty)$. Therefore, $f = q = -50.0$ cm, and the required power is

$$\mathcal{P} = \frac{1}{f} = \frac{1}{-0.500\text{ m}} = \boxed{-2.00\text{ diopters}}$$

(b) If this lens is to form an upright, virtual image at the near point of the unaided eye $(q = -13.0\text{ cm})$, the object distance should be

$$p = \frac{qf}{q-f} = \frac{(-13.0\text{ cm})(-50.0\text{ cm})}{-13.0\text{ cm} - (-50.0\text{ cm})} = \boxed{17.6\text{ cm}}$$