

Name:

**I. Short answer questions** (a paragraph each):

1. How does the notion of angular size help to explain realism in painting?
2. What was revolutionary about the invention of the pendulum clock?

**II. MCAT-type questions.** With each question choose an answer and also write one or more observations that help to justify your choice. It is possible that an answer I initially meant to be an incorrect choice could be justified.

**Reading passage:** Instead of describing a lens by its focal length  $f$ , it is also possible to describe it by its *power*  $P = 1/f$ . When  $f$  is in SI units (meters),  $P$  is in  $m^{-1}$ , also called *diopters* in this context. When two lenses with power  $P_1$  and  $P_2$  are put close together, the resulting combination has power  $P_{combination} = P_1 + P_2$ .

The locations of object and image with respect to a lens, denoted  $o$  and  $i$  respectively, are related to the focal length of the lens by  $1/o + 1/i = 1/f$ . The cornea and crystalline lens of the eye, considered as a compound lens, has a power that is variable, because the curvature of the crystalline lens can be changed by muscles that hold it in place behind the cornea. The power of the eye is variable, but the image should be on the retina for clear vision, about 2 cm behind the cornea.

1. When the muscles of the eye increase the power of the crystalline lens, the focal length of the eye will A. increase; B. decrease; C. remain the same; D. depend upon the size of the object being viewed.
2. When the eye views a star, the image will appear A. on the surface of the lens; B. between the lens and the focal point; C. at the focal point; D. beyond the focal point.
3. What is the lens power of the eye when it is focused on an object at a distance of 20 cm? A. 7 diopters; B. 50 diopters; C. 55 diopters; D. 70 diopters.

4. The lens used to correct near-sightedness will be a A. converging lens, resulting in a decreased focal length; B. converging lens, resulting in an increased focal length; C. diverging lens resulting in a decreased focal length; D. diverging lens, resulting in an increased focal length.

5. If a normal sized, far-sighted eye has a power 48 diopters, what strength corrective lens must be used so that the relaxed eye can see distant objects sharply? A. -2 diopters; B. -1 diopter; C. 1 diopter; D. 2 diopters.

6. What is the magnification in the image formed on the retina of a normal eye of an object viewed at a distance of 1 m? A. 1/50; B. 1/2; C. 2; D. 50.

**The following questions are not based on a written passage.**

7. A beam of light incident in a glass of refractive index 1.5 passes into water with refractive index  $4/3$ . If  $\theta_1$  is the angle of incidence, and  $\theta_2$  is the angle of refraction, what is the value of  $\sin(\theta_1)/\sin(\theta_2)$ ? A. 1/2; B. 8/9; C. 9/8; D. 2.

8. A ray of light in air strikes the surface of a piece of glass; the angle of incidence is  $60^\circ$ . If the reflected ray and the refracted ray are perpendicular to each other, what must be the index of refraction in the glass? A.  $2\sqrt{3}/3$ ; B.  $\sqrt{3}$ ; C.  $3\sqrt{3}/2$ ; D.  $2\sqrt{3}$ .

9. A light ray incident from inside a piece of polystyrene (index of refraction 1.55) strikes the polystyrene-air boundary. At what angles of incidence  $\theta$  between  $0^\circ$  and  $90^\circ$  will the ray be totally internally reflected? A.  $\theta < \sin^{-1}(1/n)$ ; B.  $\theta > \sin^{-1}(1/n)$ ; C.  $\theta < \sin^{-1} n$ ; D.  $\theta > \sin^{-1} n$ .

10. In terms of the focal length magnitude  $f$ , at what distances  $d$  from a convex mirror will an object produce a real image? A.  $0 < d < f$ ; B.  $f < d < 2f$ ; C.  $d > 2f$ ; D. Convex mirrors cannot form real images.

11. A pendulum swinging with an amplitude (maximum displacement) of  $10^\circ$  has a frequency  $f$ . Now it is made to swing with twice that amplitude,  $20^\circ$ , and it has frequency  $f'$ . Which one of the following statements best compares  $f$  and  $f'$ ? A.  $f' = f$ ; B.  $f' = \sqrt{2}f$ ; C.  $f' = 2f$ ; D.  $f' = 4f$ .

12. If the length of a pendulum is increased by 21%, by how much would the period increase? A. 4.6%; B. 10%; C. 21%; D. 44%.