Exam 2 Closed Book, Closed Notes, Closed Everything, HONOR CODE
NOTE EXCEPTION: For this specific exam, a calculator is permitted.

[30 pts] Multiple Choice GRE Style.

MC1. If the wavelength doubles, then the wave number

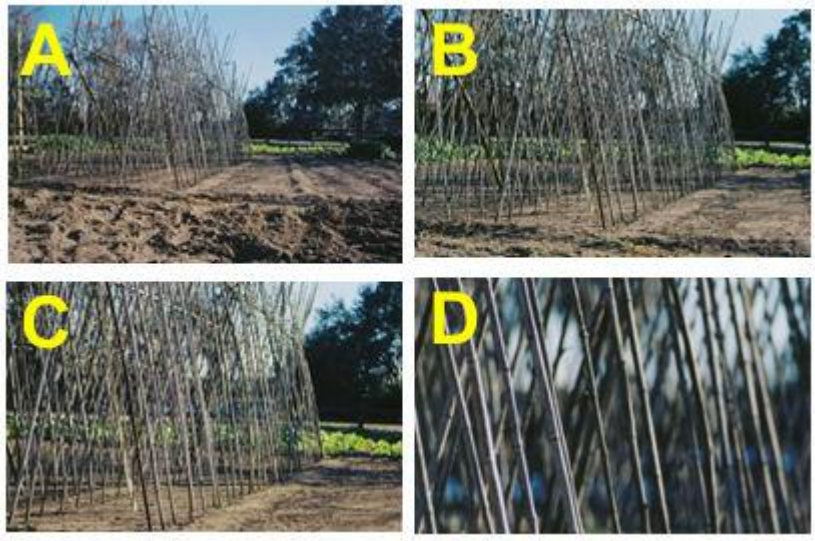
(A) becomes 1/4 of its original value
(B) halves
(C) remains the same
(D) doubles
(E) quadruples

MC2. Three different lenses, chosen from lenses with focal lengths 50 mm, 100 mm, 400 mm, and 2000 mm, were used to take the photos below.

Photo C was taken with the lens having focal length

(A) 28 mm (B) 50 mm (C) 100 mm (D) 400 mm (E) 2000 mm.

MC 3. Photo B below was taken with the normal 50-mm camera lens and two of the other photos with 28-mm and 70-mm lenses.



The fourth photo (D) was taken with a lens with a focal length of

(A) 8 mm

(B) 24 mm

(C) 35 mm

(D) 210 mm

(E) 700 mm.

MC4. What is the net focal length if a 20-cm focal lens is placed together with another 20-cm lens? (A) 0 cm (B) 5 cm (C) 10 cm (D) 20 cm (E) 40 cm

MC5. What is the visual acuity of an eye that can see the 20/30 line at 40 feet?

(A) 20/10 (B) 20/15 (C) 20/16 (D) 20/25 (E) 20/40

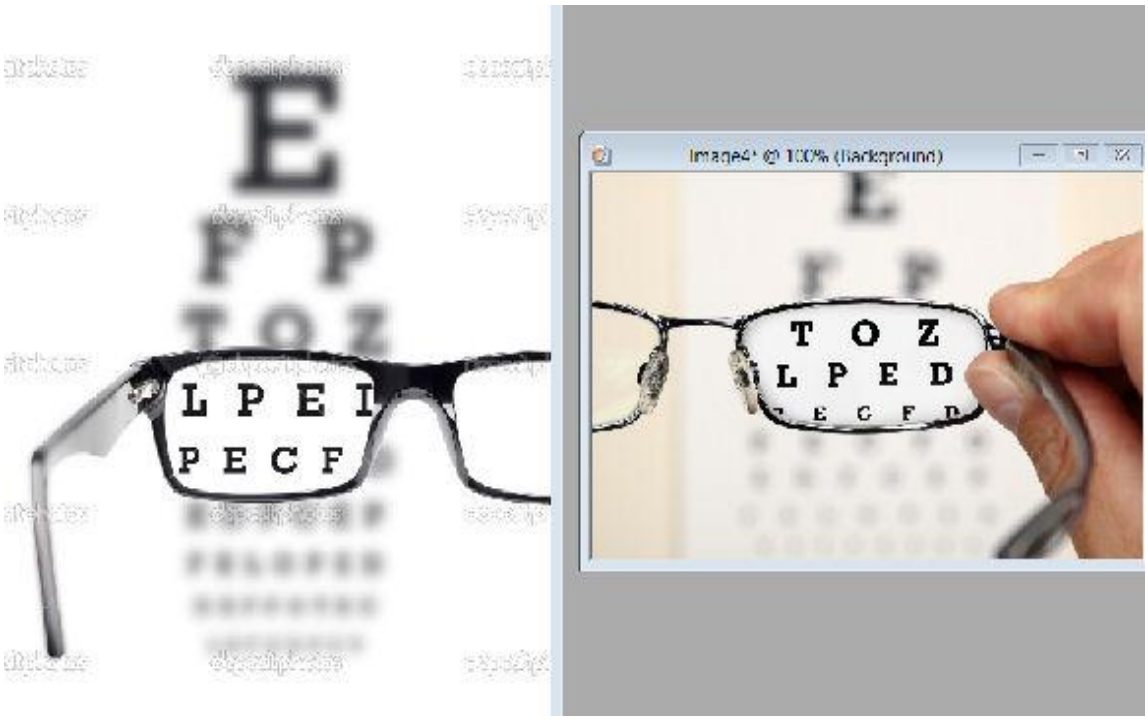
MC6. What is the prescription for a myopic eye having a far point equal to 200 cm?

(A) -0.5D (B) -1.0D (C) -1.5D (D) -2.0D (E) -2.5D

MC7. What is the prescription for a hyperopic eye having a near point equal to 200 cm?

(A) +1.0D (B) +1.5D (C) +2.5D (D) +3.0D (E) +3.5D

MC8. Each lens below is held up to an eye chart where the eye chart is the same distance away for each photo.



Which statement below is true?

(A) The glasses in the left photo are stronger than the glasses in the right photo.
(B) The glasses in the left photo and the glasses in the right photo are the same strength.
(C) The glasses in the right photo are stronger than the glasses in the left photo.

Images Courtesy depositphotos.com and imgkid.com

MC9. Sixteen-year-old Sonny has –0.5D glasses to correct his refractive error of 0.5D. With his glasses, he has no refractive error and is thus 20/20. His mother Agnes has +1.5D glasses to correct her refractive error of –1.5D. Mom Agnes Fedak Ruiz is pictured below with Sonny.

Agnes removes her glasses and puts on Sonny's, her refractive error becoming

(A) –2D

(B) –1.5D

(C) 0D

(D) 1.5D

(E) 2D.

MC10. Below, the letter n stands for index of refraction. To correct for spherical aberration

(A) the cornea is less curved at the edges and crystalline lens has less n at the edges,
(B) the cornea is less curved at the edges and crystalline lens has greater n at the edges,
(C) the cornea is more curved at the edges and crystalline lens has less n at the edges,
(D) the cornea is more curved at the edges and crystalline lens has greater n at the edges.

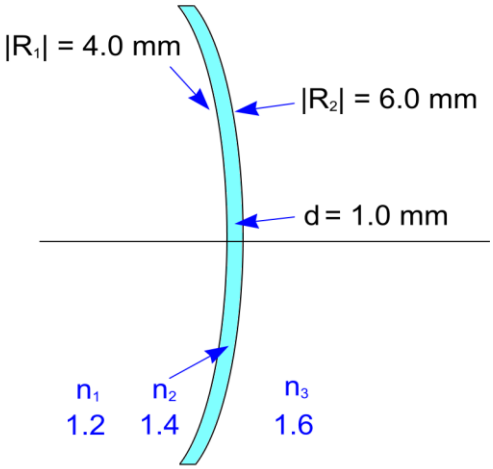
[30 pts] P1. Teleconverter. B&H Photo (https://www.bhphotovideo.com/) sells a high-quality Nikon 1.4 x teleconverter. A professional photographer buys one and inserts it between her 50-mm Nikon camera lens and the camera body. The engineer designed the teleconverter so that when the teleconverter is inserted between the 50-mm lens and camera body, the teleconverter sits L = 50 mm from the film for distant photography. Find the focal length in mm of the teleconverter that the optical engineer designed for the lens and its associated design distance in mm between the 50-mm lens and the teleconverter when in use. You may use thin-lens physics for your calculation, where the back focal length and effective focal length of the combination are given by the following formulas we derived in class. The parameter d is the distance between the two thin lenses.

$$f_b = \frac{f_2(f_1 - d)}{f_1 + f_2 - d} = L = 50 \text{ mm}$$

$$f = \frac{f_1 f_2}{f_1 + f_2 - d}$$

Give your answers to 2 significant figures.

[20 pts] P2. Dioptric Power. The generic dioptric power formula for a lens where the thickness d is incorporated is given below.



$$\frac{1}{f} = \frac{(n_2 - n_1)}{R_1} + \frac{(n_3 - n_2)}{R_2} - \frac{d}{n_2}\frac{(n_2 - n_1)}{R_1}\frac{(n_3 - n_2)}{R_2}$$

Apply this formula to the left figure and calculate the dioptric power in diopters for the optical system.

You are recommended to give the above three power components in the master formula separately first for partial credit. If you choose to do this option, clearly indicate each of these intermediate results by drawing a box around each and labeling the pieces 1, 2, and 3.

Give your final answer, i.e., the sum, also boxed off, to 2 significant figures.

[20 pts] P3. Group Velocity. In semi-classical quantum physics, a free particle moving with mass m and velocity v is taken to have kinetic energy given by $E = \frac{1}{2}mv^2$. The momentum $p = mv$ is related to a wavelength by the de Broglie relation $\lambda = \frac{h}{p}$, giving the particle a matter-wave status. The wave number has the same definition we use in class, namely, $k = \frac{2\pi}{\lambda}$. Energy is also related to the frequency with the same formula used for photons: $E = hf$ or $E = \hbar\omega$, where $\hbar = \frac{h}{2\pi}$. Use these relations as needed to calculate the group velocity per our formula $v_g = \frac{d\omega}{dk}$ and express your answer in its simplest form.