PHYS 1Cb

Spring 2014

Quiz 3 Key

Version A aabed decba

Version B edcda ebaab

Version C cdeab aabed

Version D ddaba beace

Detailed Solution

**Please note that the order of the questions differs among different test versions.*

1. Unpolarized light passes through a sequence of two polarizers whose axis of polarization for a 60 degree angle. What fraction of the intensity that enters the first polarizer will exit from the second of the two polarizers?

a) ½
b) ¼
c) 1/8
d) 1/16
e) 0

Ans. c

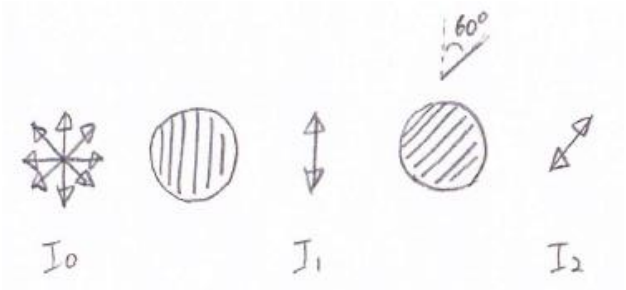
The initial light is unpolarized, so the first polarizer will let half of the intensity to pass:

$$I_1 = \frac{1}{2} I_0$$

Then the polarized light (I_1) hits upon the second polarizer, resulting inL

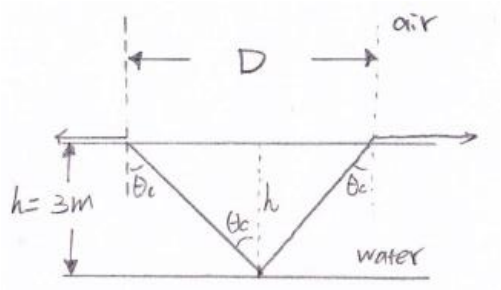
$$I_2 = I_1 \cdot \cos^2(60°) = I_1 \cdot \left(\frac{1}{2}\right)^2 = \frac{1}{4} I_1$$

Thus with respect to the intensity of the first light (I_0), the intensity if the final light (I_2) becomes $\frac{1}{2} \times \frac{1}{4} = \frac{1}{8}$ of it.



2. You are lying at the bottom of a swimming pool filled with 3m deep water (nWater = 1.33, nAir = 1). What is the diameter of the "hole" at the water surface through which you can see out of the pool?

a) 2m
b) 3m
c) 5m
d) 7m
e) 8m



Ans. d

The rim of the "hole" is where the light starts to make total internal reflection at the water-air interface (see the picture):

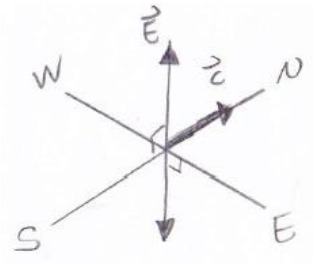
$1.33 \cdot \sin\theta_c = 1 \cdot \sin 90° \Rightarrow \theta_c = 48.75°$

The diameter of the "hole" is then $2 \cdot h \cdot \tan\theta_c = 2 \cdot 3 \cdot \tan 48.75° = 6.8$ m

d is the closest answer.

3. An electric field in an EM wave traveling north oscillates up and down. In what direction does the magnetic field oscillate?

a) north-south
b) up-down
c) northeast-southwest
d) northwest-southeast
e) east-west



Ans. e

Because the direction of the magnetic field should be perpendicular to both the direction of the electric field and the direction of the traveling light:

$$\vec{B} \perp \vec{c} \text{ and } \vec{B} \perp \vec{E}$$

The only possible direction of the oscillation is east-west.

4. What happens to a light ray as it travels from glass to air?

a) Its speed increases
b) Its speed decreases
c) Its speed stays the same but its wavelength increases
d) Its speed stays the same but its wavelength decreases
e) Its speed and wavelength both stay the same

Ans. a

Light travels faster in the air than in the glass.

The frequency doesn't change when the light enters a different medium.

The wavelength will be longer as it enters the air.

5. The three corners of a prism are at the locations (0,0), (0,5), and (6.0). White light strikes the prism at (0,3) exactly orthogonal to the prism surface. What's the angle of dispersion between red (700nm, n=1.516) and violet (400nm, n=1.538)?

a) 0.1 degrees
b) 0.3 degrees
c) 0.8 degrees
d) 1.5 degrees
e) 4.8 degrees

Ans. b

This question is exactly from practice questions (part 1). Please refer to that solution (page 7). The real answer is 2.4 degrees and b is the closest answer.

6. You are projecting 35mm slides onto a wall 2.6m from the projector. The projector has a single lens with focal length 12cm. (i) How far should the slides be from the lens? (ii) How big will the image be?

a. (i) 12.6cm (ii) -72cm
b. (i) -12.6cm (ii) 72cm
c. (i) 25cm (ii) 36 cm
d. (i) 25cm (ii) -36cm
e. (i) -25cm (ii) 36cm

Ans. a

h = 35 mm = 3.5 cm, q = 2.6 m = 260 cm, and f = 12 cm.

By the thin lens equation:

$$\frac{1}{p}+\frac{1}{q}=\frac{1}{f}$$

We have $\frac{1}{p}+\frac{1}{260}=\frac{1}{12}$ => p = 12.58 cm

To find out the size of the image, we should use the equations of magnification:

$$\mathrm{M}=\frac{h'}{h}=-\frac{q}{p}=-\frac{260}{12.58}=-20.67$$

Thus $\mathrm{h}'=\mathrm{M}\cdot\mathrm{h}=-20.67\cdot 3.5=-72.33$ cm

a is the closest answer.

7. A convex spherical mirror has a radius of curvature of 24 cm. An object is placed 6.0 cm in front of the mirror. The image position is:

a. 4.0 cm behind the mirror.
b. 4.0 cm in front of the mirror.
c. 12 cm behind the mirror.
d. 12 cm in front of the mirror.
e. at infinity.

Ans. a

C = -24 (negative because it is convex), and $f = \frac{C}{2} = -12\ cm$

p = 6 . Using the mirror equation $\frac{1}{6} + \frac{1}{q} = \frac{1}{-12}$ we get q = - 4

Negative q indicates that the image is in back of the mirror.

8. An object is 10 cm in front of a converging lens of focal length 30 cm. The image is:

a. real and smaller than the object.
b. virtual and larger than the object.
c. real and larger than the object.
d. virtual and the same size as the object.
e. virtual and smaller than the object.

Ans. b

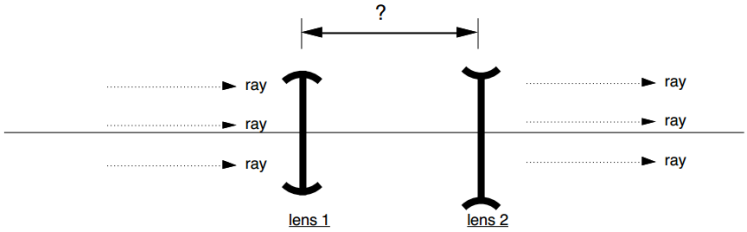
f = 30 cm and p = 10 cm. Using the thin lens equation $\frac{1}{10} + \frac{1}{q} = \frac{1}{30}$

We get q = -15 cm (negative means the image is virtual)

And the magnification is $M = -\frac{q}{p} = -\frac{-15}{10} = 1.5$

Thus the image is bigger, upright and virtual.

9. Parallel light rays (originating from the left) shine on a $f = +15$ cm converging lens (lens 1). To the right of this lens is a $f = -8.0$ cm diverging lens (lens 2). If parallel light rays then exit to the right of the second diverging lens, how far apart are the converging and diverging lenses?



a. 17 cm.
b. 15 cm.
c. 1.9 cm.
d. 5.2 cm.
e. 7.0 cm.

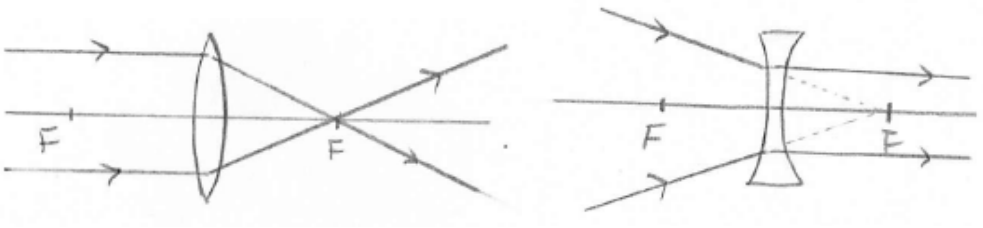
Ans. e

If we send a light parallel to the principle axis through a converging lens, the light will be converged to the focus in back of the mirror.

If we aim at the focus in back of a diverging lens and send the light to it, the diverging lens will make the refracted light travel parallel to the principle axis.

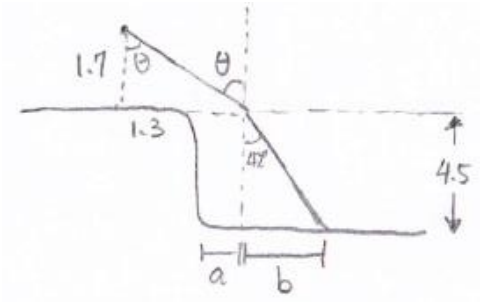
So, in order to make the above ray diagram, the focus in back of the converging lens must overlap with the focus in back of the diverging lens.

The distance between the two lenses is therefore 15 – 8 = 7 cm



10. You are standing 1.3m horizontally from the edge of a 4.5m deep lake, with your eyes 1.7m above the water surface. A diver holding a flashlight at the bottom of the lake shines the light so you can see it. If the light in the water makes a 42 degree angle with the vertical, at which horizontal distance is the diver from the edge of the lake? (Assume nWater = 1.33, nAir = 1)

a) 3m
b) 4m
c) 5m
d) 6m
e) 7m



Ans. d

From the picture above, $b = 4.5 \tan 42° = 4.05$ m

And the refraction angle of the light when it exits the water can be obtained by Snell's Law $1.33 \sin 42° = 1 \sin\theta$. We have $\theta = 63°$.

From the picture we also have the relation $1.3 + a = 1.7 \tan\theta = 1.7 \tan 63°$, and we have a = 2.04 m

Thus the distance from the diver to the edge of the lake is a + b = 6.09 m

d is the closest answer.