General Physics: Class Exam III

24 April 2019

Name: Solution **Total:** /70

Instructions

- There are 9 questions on 6 pages.
- Show your reasoning and calculations and always explain your answers.

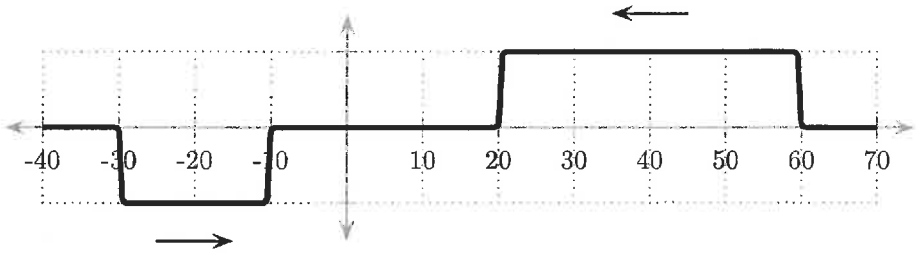
Physical constants and useful formulae

$\epsilon_0 = 8.85 \times 10^{-12}\,\mathrm{C^2/Nm^2}$ $\mu_0 = 4\pi \times 10^{-7}\,\mathrm{T\ m/A}$

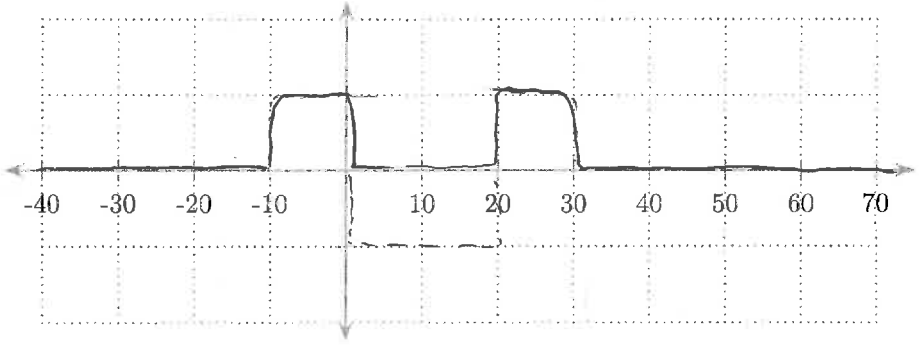
Speed of light in a vacuum: $c = 3.0 \times 10^8\,\mathrm{m/s}$

Question 1

Two pulses on a string approach each other as illustrated; a snapshot at one instant is illustrated. The grid units are each 10 cm and the pulses travel with speed 10 cm/s.



Using the axes below, sketch the appearance of the string at an instant 3.0 s later.



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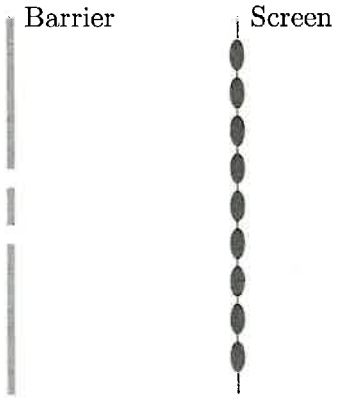
$d\sin\theta = m\lambda$ θ decreases $\Rightarrow$ λ ~~increases~~ d increases

Question 2

Light with one wavelength is incident upon a double slit and produces bright fringes on a screen as indicated. The apparatus is adjusted so that the spacing between the centers of adjacent bright fringes becomes smaller. Which of the following (choose one) is a possible adjustment that could have resulted in the reduction in spacing between the centers of adjacent bright fringes?



i) The intensity of the light was reduced.

ii) The intensity of the light was increased.

iii) The distance between the slits was reduced.

(iv) The distance between the slits was increased.

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Question 3

Light is incident upon a diffraction grating with 500 slits per millimeter (the distance between adjacent slits is 2.0×10^{-6} m). A central bright fringe is observed and the next fringe (first order) is observed at an angle of 16.3° from the central fringe.

a) Determine the wavelength of the light.

$d\sin\theta_m = m\lambda \Rightarrow d\sin\theta_1 = \lambda$ (+2)

$m=1$

$2.0\times10^{-6}\,m \sin 16.3° = \lambda$

$\Rightarrow \lambda = 560\times10^{-9}\,m$ (+2)

b) Determine the total number of bright fringes that are produced by this diffraction grating for this light.

$d\sin\theta_m = m\lambda$

$\sin\theta_m = m\frac{\lambda}{d} = m\frac{560\times10^{-9}\,m}{2.0\times10^{-6}\,m} = m\ 0.28$ (+3)

$|\sin\theta_m|$ must be ≤ 1 (+2)

$\Rightarrow m = 0, \pm1, \pm2, \pm3$ (+1 for $\pm$)

7 total (+1)

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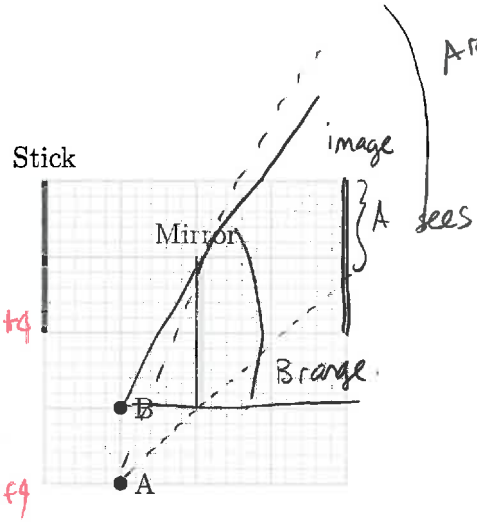
Question 4

A stick lies parallel to a flat mirror as illustrated. Two small observers, A and B, are located at the illustrated points.



a) Using the diagram illustrate the image of the stick (produced by the mirror). — eq

b) Which of the following (choose one) is true? — eq

i) Neither A nor B can see the entire image of the stick.

ii) Both A and B can see the entire image of the stick.

iii) A can see all of the image of the stick, B can only see part of the image.

(iv) B can see all of the image of the stick, A can only see part of the image.

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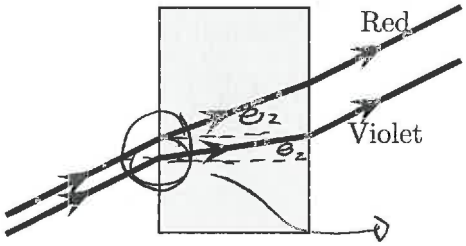
Question 5

Two light rays, one red and the other violet, pass through glass. They enter the glass traveling parallel to each other, with the red slightly above the violet. The red emerges from the glass a greater distance above the violet than at the entry point. Based on this, which of the following (choose one) is true?



i) The index of refraction of glass is larger for red light than violet light.

(ii) The index of refraction of glass is smaller for red light than violet light.

iii) The index of refraction of glass is the same for red light as for violet light.

Briefly explain your answer.

At the first interface $n_1 \sin\theta_1 = n_2 \sin\theta_2$ (θ_2 is smaller for violet.)

same for both

$n_2 = \dfrac{n_1 \sin\theta_1}{\sin\theta_2}$ ← smaller for violet

$\Rightarrow n_2$ larger for violet

smaller for red.

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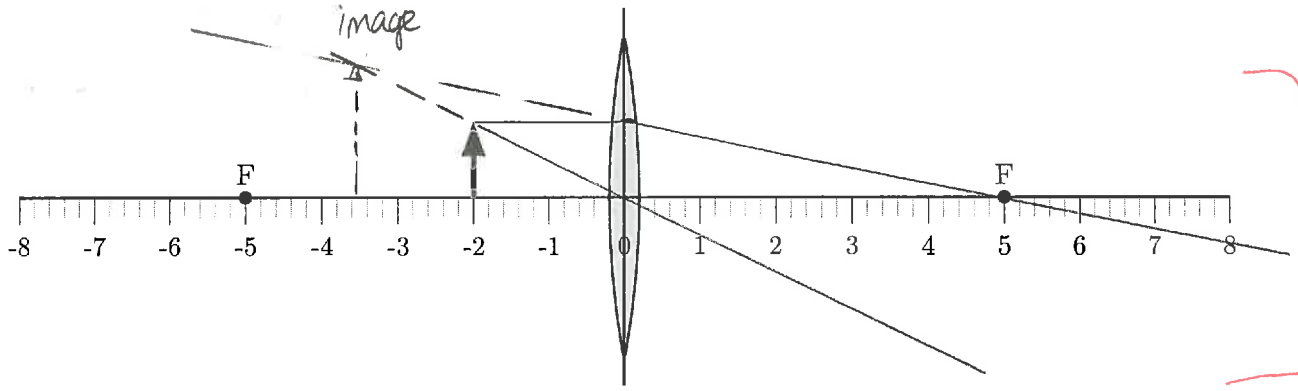
Question 6

An object, whose height is 1.0 cm, is placed to the left of a converging (convex) lens as illustrated. The focal points of the lens are labeled F. The units along the horizontal axis are centimeters.



+5

a) Trace rays as accurately as possible to indicate the image produced by the lens.

b) Determine the location and height of the image *using equations*.

location $\frac{1}{s}+\frac{1}{s'}=\frac{1}{f}$ $\Rightarrow$ $\frac{1}{2}+\frac{1}{s'}=\frac{1}{5}$ $\Rightarrow$ $\frac{1}{s'}=\frac{1}{5}-\frac{1}{2}$

$\Rightarrow \frac{1}{s'}=\frac{2-5}{10}=\frac{-3}{10}$

$\Rightarrow s'=-\frac{10}{3} \Rightarrow$ $s'=-3.33$ m

+3

height $m=h'/h \Rightarrow h'=hm$

But $m=-s'/s=-\left(\frac{-3.33\,cm}{-2\,cm}\right)=1.67$

So $h'=1.67\times 1.0\,cm=1.67\,cm \Rightarrow$ $h'=1.67$cm

+4

Question 6 continued ...

c) Someone claims that it is possible to insert a sheet of cardboard at some location in the vicinity of the lens so that the image, produced by this lens (from the object as illustrated above), can be captured clearly on the cardboard. Is this true or false? Explain your answer.

No, light rays do not actually travel to the image. They only appear to have traveled from the image. So one cannot capture image on a piece of cardboard.

+4 +4

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Question 7

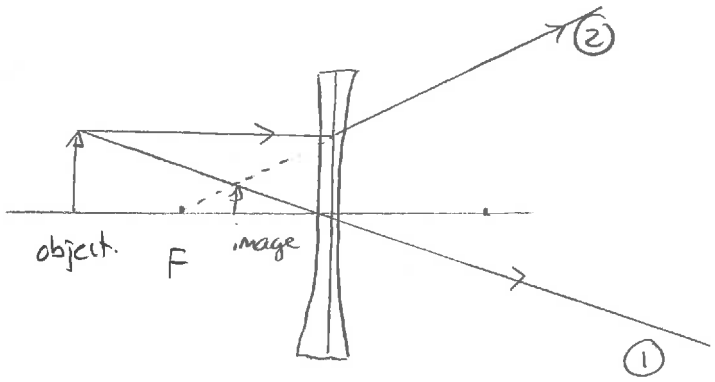
An object is placed to the left of a concave (diverging) lens. Which of the following (choose one) is true regarding the image produced by the lens?

i) The image will always be located between the left focal point of the lens and the lens.

ii) The image can be located to the right of the lens; this depends on the object's location.

iii) The image can be located to the left of the left focal point of the lens; this depends on the object's location.

Briefly explain your answer.



The intersection point will always be somewhere along the dashed line. This lies between F and lens. So image is always between left focal pt and lens.

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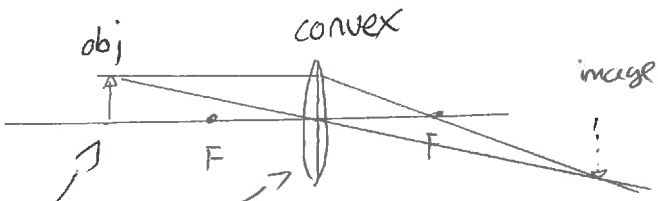

Question 8

A projector uses a single lens to create an image from an object. The object is to the left of the lens and the image is to the right of the lens. Which of the following (choose one) will accomplish this?

i) A convex lens with the object between the lens and the focal point.

ii) A convex lens with the object beyond the focal point.

iii) A concave lens with the object between the lens and the focal point.

iv) A concave lens with the object beyond the focal point.

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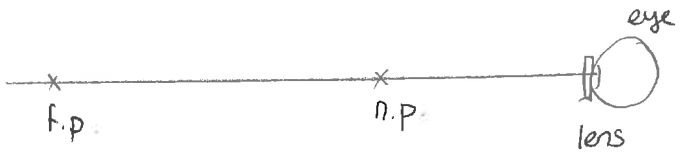
Question 9

A nearsighted person has a far point of 5.0 m and a near point of 0.20 m. The person wears corrective lenses which are placed against the eye (e.g. contact lenses) that enables the person to see an object that is infinitely far away clearly. Determine a maximum focal length for the corrective lenses that will accomplish this. Describe whether the lenses are converging or diverging.



Need to take an object at infinity and create image at n.p

$s = \infty$

$s' = -5.0\,m$

$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$

$\frac{1}{\infty} + \frac{1}{-5.0\,m} = \frac{1}{f}$

$\Rightarrow f = -5.0\,m$

Negative f $\Rightarrow$ diverging lens

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