General Physics: Class Exam III

24 April 2013

Name: Solution **Total:** /70

Instructions

- There are 8 questions on 6 pages.
- Show your reasoning and calculations and always justify your answers.

Physical constants and useful formulae

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

Question 1

The red light emitted by a helium neon laser has wavelength $632.8 \times 10^{-9}\,\text{m}$ in a vacuum. The light passes travels through 2.0 m of a special type of glass in time $9.3 \times 10^{-9}\,\text{s}$. Determine the index of refraction of this glass **and** the wavelength of light in the glass.

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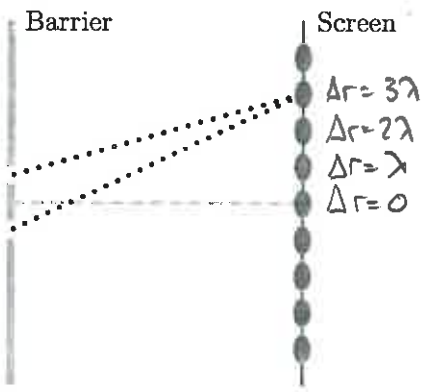
Question 2 70 but low on(b)

Light of wavelength 590×10^{-9} m is incident upon a double slit and produces bright fringes on a screen as indicated.



a) Which of the following (choose one) would occur if the separation between the slits were increased to double of what it originally was?

i) Nothing would change.
ii) The bright fringes would be in the same places but would become dimmer.
iii) The bright fringes would be further apart.
(iv) The bright fringes would be closer together.

} 5

b) The dotted lines indicate the paths taken by light to travel from each of the slits to a particular bright fringe. The light from the lower slit has traveled a further distance than that from the upper slit. By how much further has it traveled?

} 3

The lower travels $\Delta r = 3\lambda$ further to produce constructive interference.

$\Delta r = 3\lambda = 3 \times 590 \times 10^{-9}\,m$

$= 1770 \times 10^{-9}\,m$

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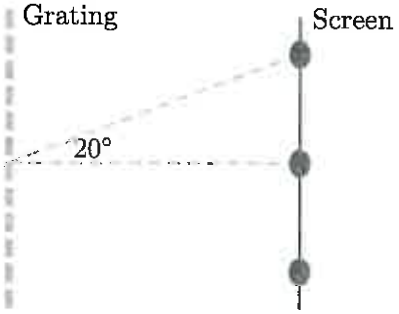
Question 3 9;

Light is incident on a diffraction grating and it produces a pattern of bright fringes as illustrated. The fringe in the middle of the screen on the diagram is directly opposite the incoming light beam. The distance between adjacent slits in the diffraction grating is 1.9×10^{-6} m. Determine the wavelength of the light.



$d \sin\theta_m = m\lambda$ $\quad m = 1$

$1.9 \times 10^{-6}\,m \sin 20^\circ = \lambda$

$\Rightarrow \lambda = 650 \times 10^{-9}\,m$

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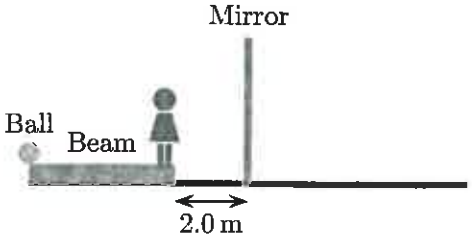
Question 4 91

A beam, of length 4.0 m, lies to the left of a mirror. A ball is on the left end of the beam. A person stands on the right end of the beam. How far to the person's right does the image of the ball appear to be (to the person standing on the beam)? Explain your answer.



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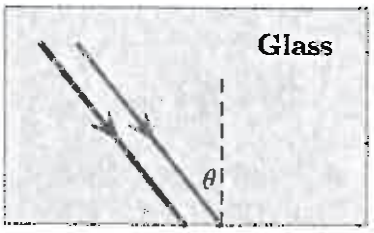
Question 5 36

Red and violet light rays travel parallel to each other through glass toward the edge of the glass, where it meets air. While keeping the rays parallel to each other, the angle θ from the normal is increased starting from $\theta = 0°$. Initially both colors emerge into the air. As θ is increased, which, if any, of the colors will be the first to disappear from the air (i.e. no longer emerge from the glass)? The index of refraction of the glass is 1.54 for violet light and 1.52 for red light. The index of refraction for both in air is 1.00. Explain your answer.



5 [The ray disappears when $\theta > \theta_c$

Violet $\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right) = \sin^{-1}\left(\frac{1}{1.54}\right) = 40.49°$

Red $\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right) = \sin^{-1}\left(\frac{1}{1.52}\right) = 41.14°$

3 [Violet has smaller critical angle than red. Violet disappears first

+1 +2

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Question 6 §1

Light passes from air into one medium (labeled medium 1), with index of refraction n_1, and from there into another medium (labeled medium 2), with index of refraction n_2. The index of refraction of air is denoted n_{air}. Which of the following (choose one) is true?

a) $n_{\text{air}} < n_1 = n_2$

b) $n_{\text{air}} < n_1 < n_2$

c) $n_{\text{air}} < n_2 < n_1$

d) $n_2 < n_1 < n_{\text{air}}$

e) $n_1 < n_2 < n_{\text{air}}$

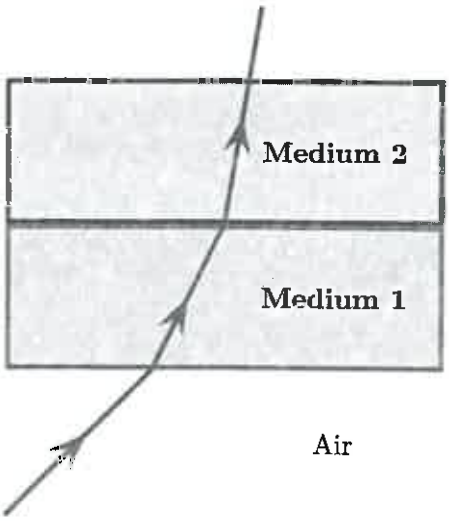
smaller n → larger n

⇐) bend toward normal

In both cases bend toward normal. So

$n_1 > n_{air}$

$n_2 > n_1$



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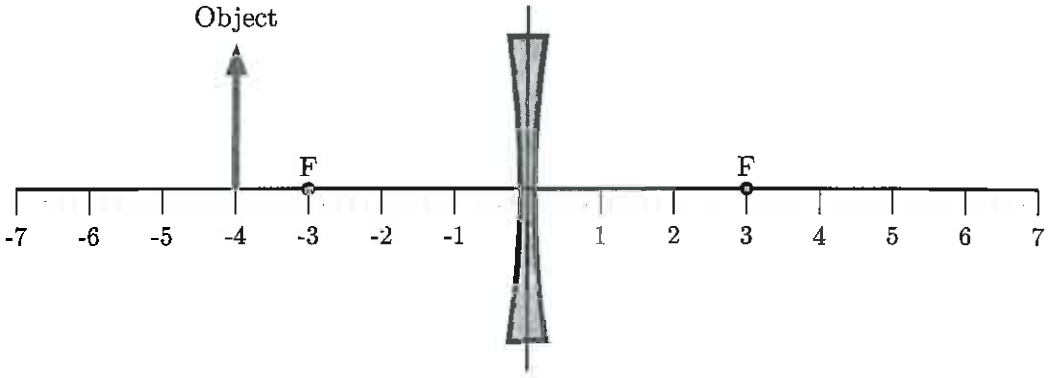
Question 7 §2

An object, whose height is 2 cm, is placed to the left of a concave lens as illustrated. The focal points of the lens are labeled, F. The units along the horizontal axis are centimeters.



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*.

Question 7 continued ...

c) Zog claims that it is possible to use this lens to produce an enlarged image of the object using just this lens. Is Zog's claim **true or false? Explain your answer.**

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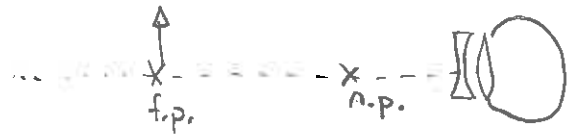
Question 8 5.5 low on pt b

Geraldine has a near point of 35 cm = 0.35 m and a far point of 1.25 m.

a) Determine the (maximum) focal length of the corrective lenses which allow Geraldine to see all distant objects clearly. Are these lenses are converging or diverging?



object

Make image at f.p

1 [So $s' = -1.25\text{m}$ (negative because same side of lens as object)

1 [$s = \infty$

2 [$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$ $= 0$ $\frac{1}{\infty} + \frac{1}{-1.25\text{m}} = \frac{1}{f}$ $= 0$ $f = -1.25\text{m}$

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1 [negative f $= 0$ diverging

b) When Geraldine wears these corrective lenses, which (choose one) of the following is true?

i) The closest that she can see clearly is 0.35 m.
ii) The closest that she can see clearly is less than 0.35 m.
iii) The closest that she can see clearly is more than 0.35 m.

Briefly explain your answer.

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Image will have to be at n.p. For a diverging lens, the object is always further than image, so the object would be further than the n.p to get a clear image at n.p. This is the closest she can see clearly.

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