Physics 123B
Autumn 2019

123B-MAJUMDAR

Exam 2
Nov. 7, 2019

Printed Name SINHA (*last*) IRIKA (*first*) **Seat Number** B24

I certify that the work I shall submit is my own creation, not copied from any source, and that I shall abide by the examination procedures outlined below.

Signature ______________ **Student ID Number** 1732892

READ THIS ENTIRE PAGE NOW, BEFORE THE HALF-HOUR BELL.
Do not open the exam before the half-hour bell.
You will have 60 minutes after the bell to complete the examination.
Exam papers will no longer be accepted after 61 minutes have elapsed.
NO CELL PHONES, TEXT MSG, etc. ALLOWED AT ANY TIME

Before the exam begins:

- Print and sign your name, and write your student ID number and the number of your seat in the spaces on this page (above).
- Write your name and student ID number on your bubble sheet, and fill in the corresponding "bubbles" using **dark** pencil marks.

During the exam:

- **Important first step:** Print your name and student ID at the top of **each** page.
- If you are confused about a question, raise your hand and ask for an explanation.
- If you cannot do one part of a problem, move on to the next part.
- This is a closed book examination. You have access to the equation sheet included with this exam and to things written on the classroom board by the instructor.
- You may use a calculator, but you **may not use** text storage capabilities, graphics capabilities, internet connections, phones, nor any programmable device.
- You may not use scratch paper, you may not communicate with any person.

For multiple-choice problems (those on white paper):

- Fill in bubble sheets carefully and **darkly**. Make no stray marks. Erase carefully.
- Also circle your choices directly on the exam paper for later reference.

For hand graded problems (those on colored paper):

- If you need more space than is available to answer any part of a problem, use the **back side of the same page** to complete your answer. Clearly indicate to the grader that you used the back side. Do not use scratch paper.
- Show your work in enough detail so that the grader can follow your reasoning and your method of solution. Circle your answers, and state units if appropriate. For numerical answers significant figures should match the number of significant figures in the numerical values given in the problem (usually 2 or 3).

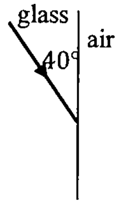
Name: SINHA IRIKA
Last *First*

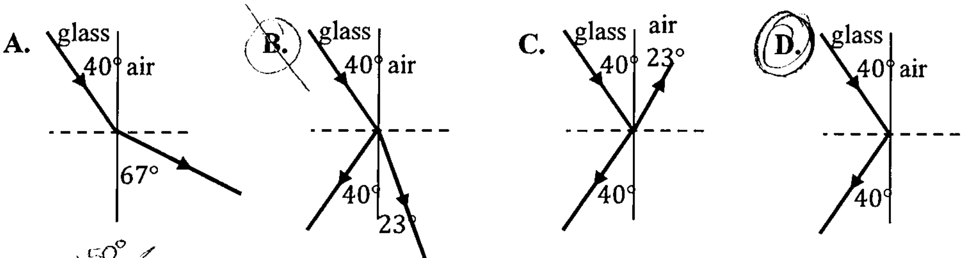
Lecture Multiple Choice Questions [9 questions; 40 points total]

1) [4 pts] A person stands in front of a vertical mirror to view her own image. Which statement is correct?
   A) The image is always upright for a planar mirror ✓
   B) The image is always smaller for a concave mirror
   C) The image is always inverted for a convex mirror
   D) She can increase distance from the planar mirror to view her own entire image regardless of the amount of mirror.
   E) All of the above are correct.

A

2) [4 pts] A light ray in glass ($n = 1.65$) strikes a surface with air on the other side, as shown. Which ray diagram best illustrates all paths the light will take after striking the surface?





D

50°

$n=1$

$n_1 \sin\theta = n_2 \sin\theta$

$\frac{1}{n_1} = \sin\theta$

$n_1 \sin\theta = n_2 \sin\theta$

40 sin

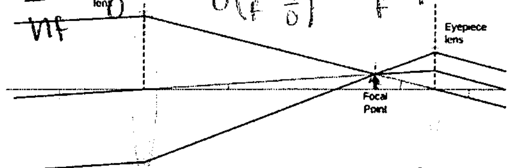
$n_1 \sin\theta = n_2 \sin\theta$

$\frac{n_1}{n_2} \sin 50$

3) [4 pts] A telescope is composed of two convex lenses with angular magnification 100. The focal length of the objective lens is 50 cm. What is the focal length of the eye piece lens?
   A. 0.1 cm
   B. 0.5 cm
   C. 2 cm
   D. 4 cm
   E. 2000 cm

C

$M_\theta = \frac{\theta_i}{\theta_o} = \frac{h_i}{h_f} = \frac{-i}{o} = \frac{-1}{o\left(\frac{1}{f}-\frac{1}{o}\right)} = \frac{-1}{\frac{o}{f}-1} = 100$



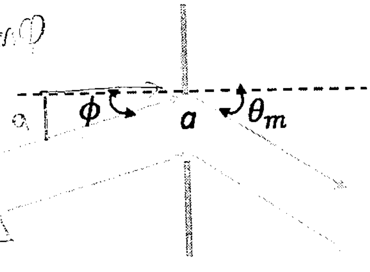
$100\frac{o}{f} - 100 = -1$

$\frac{o\,100}{99} = f$ $\frac{o}{f} = \frac{99}{100}$

7) [5 pts] Light of a certain wavelength λ is incident at an angle ϕ with the normal to a vertical plane. The plane has one slit of width a. Find the angle θ_m at which diffraction minima are observed. Express the answer in terms of ϕ, θ_m, a and m, where m is an integer.

A) $a\sin(\phi) = m\lambda$
B) $a\sin(\theta_m) = m\lambda$
C) $a\sin(\phi) + a\sin(\theta_m) = m\lambda$
D) $a\sin(\phi) + a\sin(\theta_m) = (m + \frac{1}{2})\lambda$
E) None of the above

D



$a\sin\theta_{min} = \pm n\lambda$

8) [5 pts] How fast must a neutron move in order to have a de Broglie wavelength of lambda equal to $10^{-9}m$? (the mass of neutron is $1.67 \times 10^{-27}\ kg$.)

A. 6.63×10^{-25} m/s
B. 3.97×10^{-10} m/s
C. 397 m/s
D. 3.97×10^{8} m/s
E. 6.63×10^{8} m/s

C

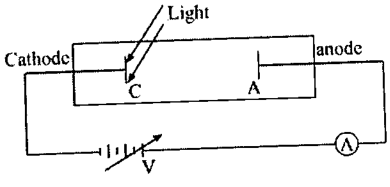
$V = \frac{h}{m\lambda} = \frac{6.626 \cdot 10^{-34}}{10^{-9} \cdot 1.67 \cdot 10^{-27}}$

$\frac{6.626 \cdot 10^{2}}{1.67}$

9) [5 pts] In a photoelectric experiment, the work function for a material is E_0. Light having a wavelength λ with intensity I_0 falls on the material at the electrode C. The negative terminal of a battery is connected to the electrode C. The ammeter measures non-zero current when the electric potential V is set to zero. To double the photoelectric current, how would you change the setup?

A) ~~Double the electric potential V~~
B) Double the intensity of light
C) Double the wavelength of light
D) Halve the wavelength ✓
E) None of the above

B

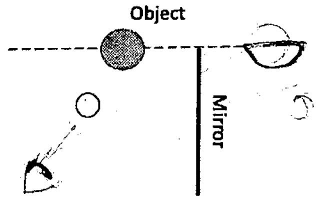


$V = IR = QV = J$

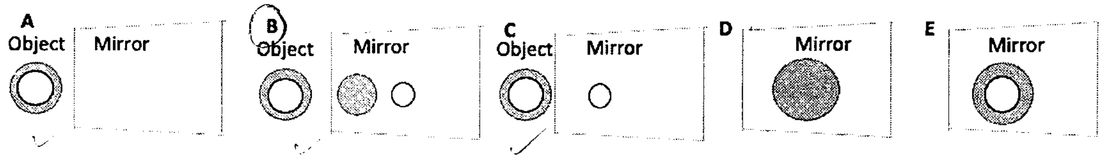
$\frac{\uparrow J}{\downarrow Q} = \uparrow IR$

Part II. Lab Questions [3 question, 16 points total]

10) [5 pts] An experimenter sets up the situation shown at right, with a smaller ball, a larger ball and a plane mirror. The balls are aligned as shown, with the center of the larger ball along the dotted line running perpendicular to the mirror at its edge. The experimenter sights directly down the line of balls with one eye open. What does the experimentalist see?

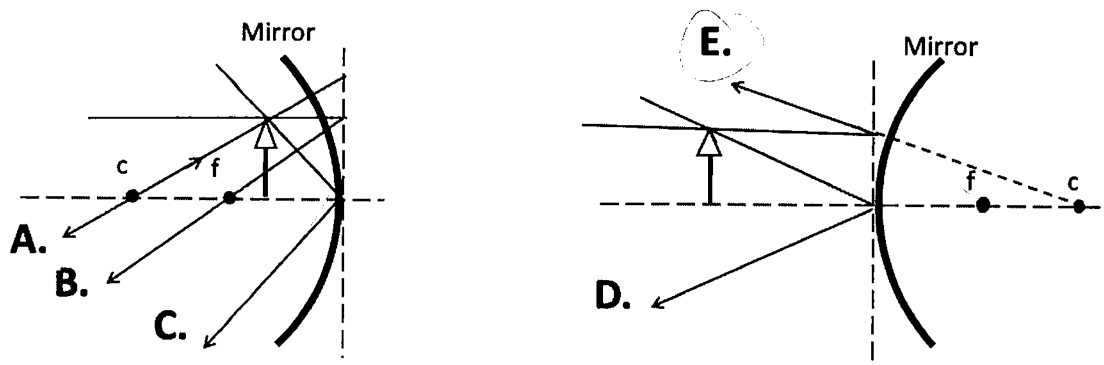


B



11) [5 pts] In each diagram below, determine which ray is incorrectly drawn ("bad"), according to the rules for the principal rays in ray diagrams for mirrors. The rays are labeled closest to the arrowhead corresponding to the outgoing part of the ray.

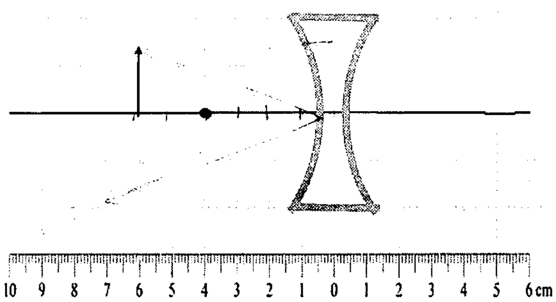
E



12) [6 pts] An object indicated by the arrow below is located $d_1 = 6$ cm from a lens with focal length of $f = 4$ cm. Where will the image be located with respect to the lens?

A. 2.4 cm, left **B.** 2.4 cm, right **C.** 12 cm, left **D.** 12 cm, right **E.** 20 cm, left

A



$\frac{1}{f} - \frac{1}{o} = \frac{1}{i}$

$\frac{-1}{4} - \frac{1}{6} = \frac{1}{o}$

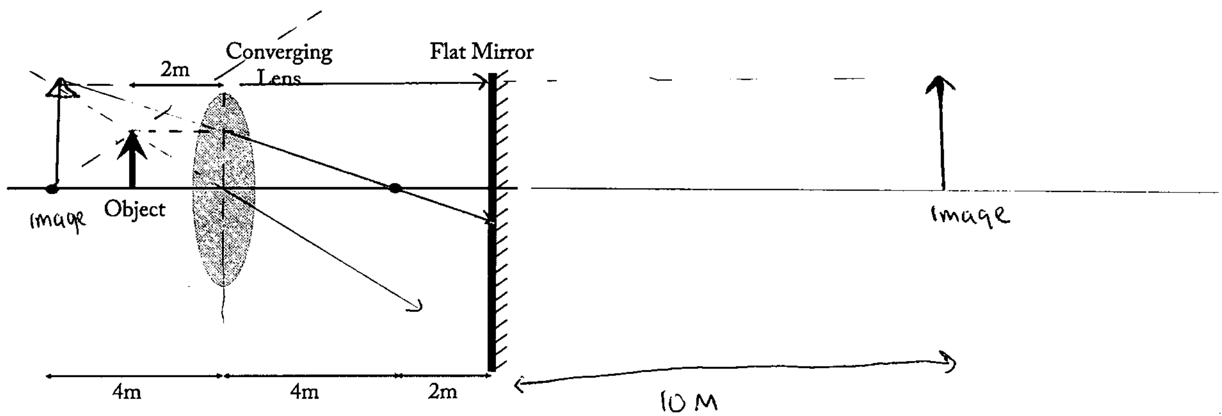
Name: SINHA IRIKA
Last First

Lecture Free Response [26 Points] 25

Show detailed work to get full credit.

A. [8 pts] A converging lens with a focal length 4 m is placed 6 m in front of a flat mirror (see the figure below). An object is placed 2 m farther from the mirror as shown. Draw a ray diagram to show any image(s) formed by this arrangement of lens and mirror. Draw any real rays as solid lines, and any virtual rays as dashed lines. You can assume the mirror and the lens are infinite in size. Also assume that all the rays are paraxial.

8



[6 pts] Using the lens and mirror equations, calculate the distance(s) of any image(s) from the lens. In each case, state whether the image is real or virtual?

5

converging lens: $\frac{1}{f} - \frac{1}{o} = \frac{1}{i}$

$\frac{1}{4} - \frac{1}{2} = \frac{1}{i}$ ∴ $i = -4m$ virtual image

Image behind lens is virtual

flat mirror: $i = +16m$ real image

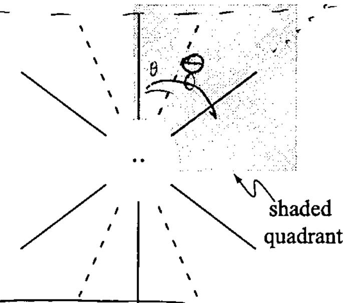
image behind mirror is real

6m (lens to mirror) + 10m (behind mirror) = 16m

Name SINHA IRIKA Student ID 1732892 Score 14.15
last *first*

IV. [18 points total] Tutorial question. This question consists of two independent parts, A and B.

A. The diagram at right shows all the nodal lines (dashed) and all the lines of maximum constructive interference (solid) due to two point sources that generate periodic waves in a tank of water.



i. [4 pts] Determine the source separation in terms of λ. If it is not possible to determine the source separation exactly, determine the source separation as closely as you can by giving the smallest range into which the source separation must fall. Explain.

3

$d\sin\theta = m\lambda$ m=1 for first antinode

$45° < \theta < 90°$

$\frac{\sqrt{2}}{2} < \sin\theta < 1$

$d = \frac{\lambda}{\sin\theta}$ ∴ $\boxed{\lambda < d < \frac{\lambda 2}{\sqrt{2}}}$

ii. Suppose the previous experiment is changed so that the frequency of the waves generated by the two point sources is *increased by a factor of 2*.

2

[4 pts] How many lines of *maximum constructive interference* will now appear in the shaded quadrant on the diagram? Explain.

$\sin\theta$ ~~doubles~~ halved

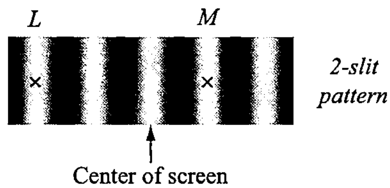
∴ θ halved?

$\sin\theta \approx \theta$

$d\sin\theta = (n+\frac{1}{2})\lambda = (n+\frac{1}{2})\frac{c}{f}$

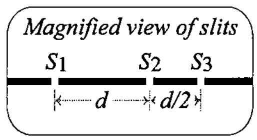
4 lines of constructive interference because θ will ~~increase~~ decrease in response to f increasing. Double the original

B. The photograph at right shows the pattern created on a distant screen when monochromatic light from a laser is incident on two identical slits, S_1 and S_2, separated by a distance d.



Point M marks the location of the first maximum to the right of the central maximum as shown. Point L marks the location of the second maximum to the left of the central maximum.

A third slit (S_3) of equal width is uncovered a distance $d/2$ to the **right** of the right slit (S_2), as shown in the magnified view at right.



i. [5 pts] After the third slit is opened, will point M be *a point of maximum constructive interference* (a principle maximum), *a point of zero intensity* (a minimum), or *something in between?* Explain.

5

$d\sin\theta = m\lambda = \lambda$ @ M

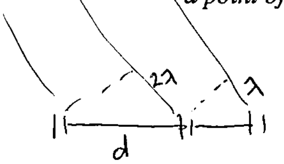
basically you get constructive from S_1 & S_2 w/ λ diff and destructive from S_3 w/ $\lambda/2$ → overall $\lambda/2$

~~which is neither min nor max~~

also S_1 & S_2 constructive but S_3 is not → something in between ~~something in between~~

ii. [5 pts] After the third slit is opened, will point L be *a point of ~~maximum constructive~~ constructive interference, a point of zero intensity,* or *something in between?* Explain.

5



$d\sin\theta = 2\lambda$ @ L

$\frac{3d}{2}\sin\theta = 2\lambda(\frac{3}{2}) = 3\lambda$ → maximum constructive