EXAM 2

203-NYC-05 — Waves, optics and modern physics

Fall 2016 **Name:**

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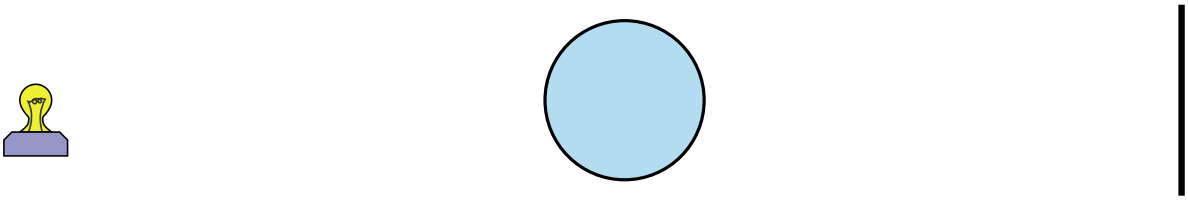
Instructions

- For questions 1 to 10, only the correct answer(s) is(are) needed.
- For questions 11 to 14, clearly expose every step of your solution. Points will be awarded to sketches, explanations and calculations, not only to the final values.
- Be precise in all your calculations: the first three digits in the final value must be correct for an answer to be considered valid. Units are also mandatory.

Question 1 [3 points]

A small light bulb is placed at a great distance in front of a transparent sphere ($n = 2.5$), with a screen at a great distance on the other side. What kind of lens should be used, and where should it be placed, in order to project a real image of the light bulb onto the screen?



Select every possible solution.

a) A converging lens between the sphere and the screen.

b) A converging lens between the light bulb and the sphere.

c) A diverging lens between the sphere and the screen.

d) A diverging lens between the light bulb and the sphere.

e) None of the above can work.

Question 2 [3 points]

What kind of ametropia results in the punctum remotum being located *behind* the eye?

a) Astigmatism.

b) Hyperopia.

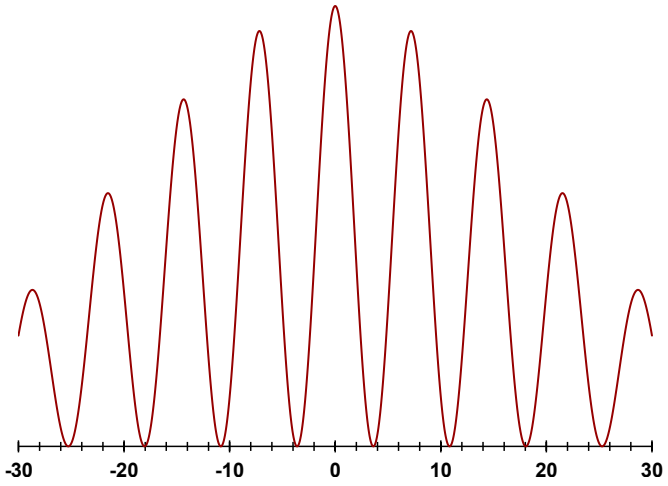
c) Myopia.

d) Presbyopia.

e) Strabismus.

Question 3 [3 points]

A laser beam ($\lambda = 650\,\text{nm}$) is sent onto "something", with a screen placed very far away on the other side of that "something". The intensity of the light incident on the screen is shown on the graph below, where the distances are in centimetres.



What could this "something" be? *You get no points by answering e).*

a) A single narrow slit.

b) Two narrow slits.

c) Three narrow slits.

d) A grating (high number of slits).

e) This is impossible. This is witchcraft!

Question 4 [3 points]

Sound waves cannot be polarized because...

a) ... the speed of sound is too small.

b) ... sound needs a physical medium to propagate.

c) ... the speed of sound varies with temperature.

d) ... sound is a longitudinal wave.

Question 5 [3 points]

We make Young's experiment using two slits, a green laser and a far-away screen. What happens if we increase the width of each slit without changing the distance between them?

a) The interference maxima gets more spread out.

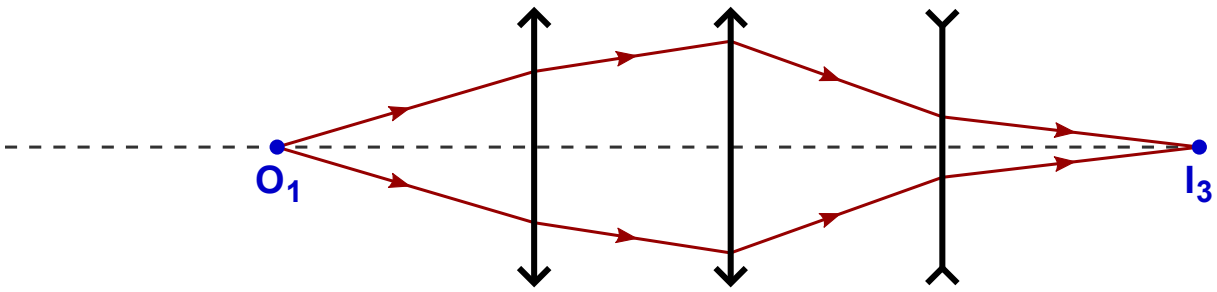
b) The width of the central diffraction maximum increases.

c) There are fewer interference maxima within the central diffraction maximum.

d) A secondary maximum appears between each interference maximum.

Question 6 [3 points]

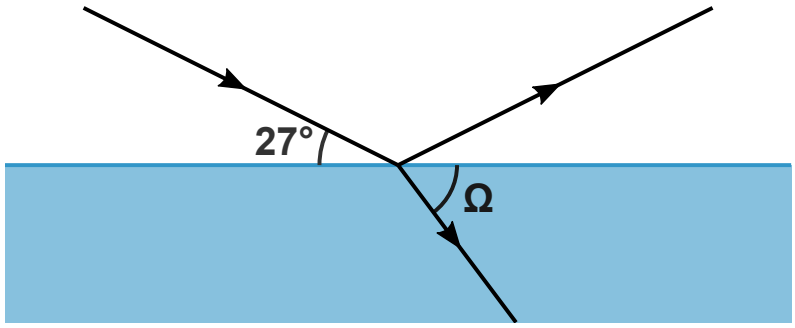
Directly on the figure below, identify the positions of the missing objects (O_2 and O_3) and images (I_1 and I_2) and, for each, add a "R" or a "V" to state if it is *real* or *virtual*.



Question 7 [3 points]

Unpolarized light travelling through air hits a transparent medium in such a way that the reflected light is entirely polarized. What is the value of the angle Ω?

Answer: $\Omega =$



Question 8 [3 points]

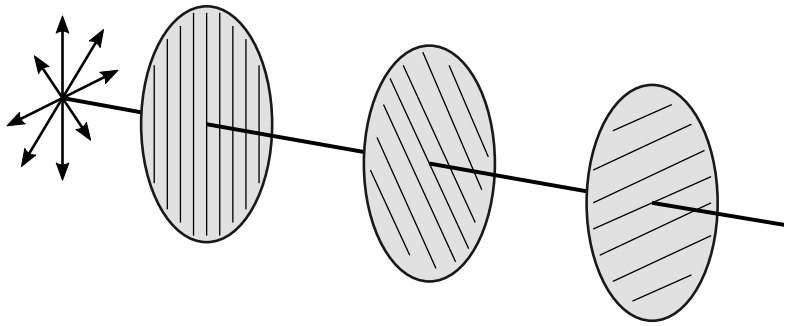
We observe 7 bright fringes on a wall when we send violet light ($\lambda = 420\,\text{nm}$) through a grating. If we replace the violet laser by a red laser ($\lambda = 650\,\text{nm}$), how many bright fringes will we observe?

Answer:

Question 9 [3 points]

Unpolarized light passes through three polarizing filters. The axis of transmission of the first filter is perfectly vertical, the axis of the second filter makes a 30° angle with the vertical, and the axis of the third filter is perfectly horizontal. What percentage of the initial intensity gets transmitted through these three polarizing filters?

Answer:



Question 10 [3 points]

We want to distinguish the two stars forming a binary system using a telescope. Which of the following options can help dissociate the two stars?

Select the two correct options. You get no points by answering e).

a) Using a sensor only sensitive to short wavelengths.

b) Using a sensor only sensitive to long wavelengths.

c) Using a telescope with a small mirror.

d) Using a telescope with a large mirror.

e) It will never work... you should give up!

Question 11 [18 points]

A candle is placed 180 cm in front of a screen. The flame of the candle has a height of 2 cm.

a) [9 pts] Where should a converging lens ($f = 40$ cm) be placed in order to have a clear image of the flame on the screen? *Give the two possible answers.*

b) [9 pts] What is the height of the image of the flame on the screen? *Give the two answers, one for each of the answers provided in subquestion a).*

Question 12 [20 points]

A laser beam (frequency of 4.61×10^{14} Hz) is sent through a single slit having a width of 0.1 mm. A screen is placed 5 m from the slit.

a) [8 pts] On the screen, what is the width of the central maximum?

b) [7 pts] On the screen, what is the intensity (relative to the intensity of the central maximum) 1 cm away from the centre of the central maximum?

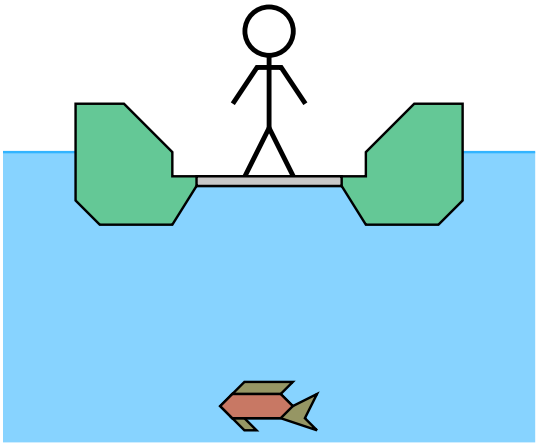
c) [5 pts] If the room is perfectly dark, the screen infinitely wide and the laser very intense, how many diffraction maxima can be observed?

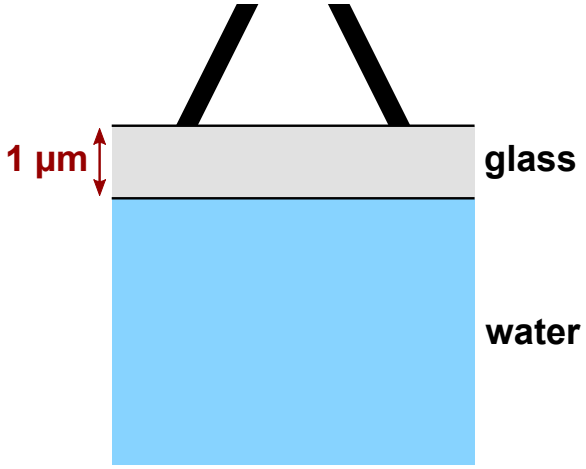
Question 13 [15 points]

During an expensive vacation (he can afford it), Luc is on a boat which has a glass ($n = 1.5$) floor allowing to see the fish swimming in the water ($n = 1.33$) below. The glass floor has a thickness of only 1 µm. *But don't worry, Luc is light as a feather, so it won't break.*

a) [10 pts] Within the visible spectrum (from 400 nm to 700 nm), which wavelengths are not present in the reflected light? *Give all the possible values within this range.*

b) [5 pts] If a fish appears to be 3 m below the glass floor, what is its actual position? *Neglect the glass floor: assume the light coming from the fish goes directly from water to air.*





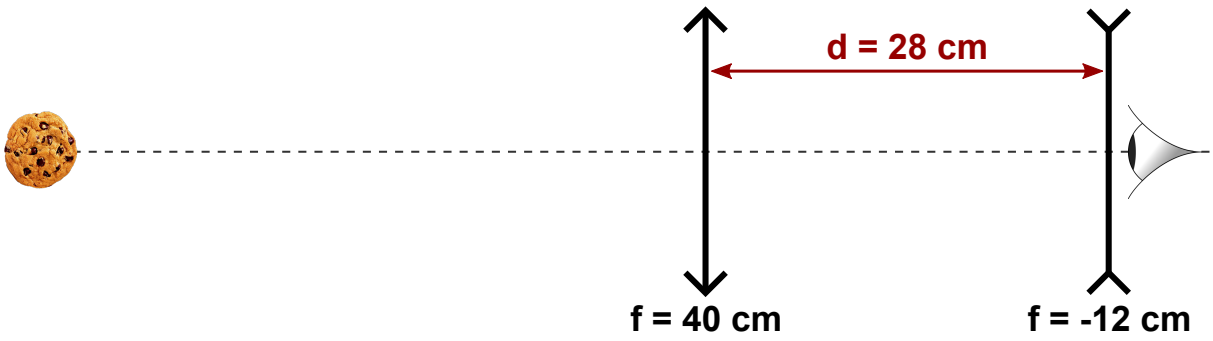
Question 14 [17 points]

Jean-Raphaël looks at a very interesting cookie through a Galilean telescope of his making. The cookie has a diameter of 8 cm and is placed 20 m away from the objective (converging lens). Jean-Raphaël places his eye very close to the ocular (diverging lens).

a) [8 pts] Determine the position of the image made by the telescope. *Give the distance relative to Jean-Raphaël's eye.*

b) [2 pts] Suffering from a mild myopia, Jean-Raphaël has a punctum remotum located at 2 m. Can he see the cookie clearly, when looking through this telescope, or is the image blurred?

c) [7 pts] How much bigger does the cookie appear through the telescope compared to when Jean-Raphaël looks at it, from the same distance, without the telescope?



Answers

1. a-b-d 2. b 3. b 4. d 5. c 7. 63°

8. five bright fringes 9. 9.375 % 10. a-d

11. a) $p_1 = 0.6\,\text{m}$, $p_2 = 1.2\,\text{m}$ b) $y_{i1} = -4\,\text{cm}$, $y_{i2} = -1\,\text{cm}$

12. a) 6.503 cm b) 0.725 08 I_0 c) 307 diffraction maxima

13. a) 600 nm, 500 nm, 428.57 nm b) 3.99 m

14. a) 1.884 m in front of his eye b) He sees the cookie clearly c) $G = -3.229$