St John Baptist De La Salle Catholic School, Addis Ababa

Grade 10 Physics Midterm Examination

4^{th} Quarter

May, 2023

Notes, and use of other aids is **NOT** allowed. Read all directions carefully and **write your answers in the answer sheet**. To receive full credit, you must show all of your work.

Name:_____ Roll Number:_____ Section:___Time Allowed: **60 minutes**

Multiple Choice Questions

1. When light travels from medium A to medium B, it refracts towards the normal. Which of the following is true?

   A. Light travels faster in medium B than medium A.

   B. The wavelength of light in medium B is larger than its wavelength in medium A.

   C. The frequency of light in medium B is larger than its frequency in medium A.

   D. The refractive index of medium B is greater than that of medium A's.

   Answer: D

2. If the amplitude of the electric field on an electromagnetic wave is $3 \times 10^6 V/m$, what is the amplitude of the magnetic field?($c = 3 \times 10^8 m/s$)
   A. $3 \times 10^2 T$ B. $1 \times 10^6 G$ C. $3 \times 10^2 G$ D. $1 \times 10^{-2} T$
   Answer: D

3. Why are ELF radio waves used for communication instead of say, UHF or VHF, radio signals?

   A. ELF radio waves have larger wavelengths which implies that they are able to carry more information per pulse to transfer into submarines.

   B. ELF radio waves have larger frequencies which implies that they are able to carry more information per pulse to transfer into submarines.

   C. ELF radio waves have larger wavelengths which implies that they are able to travel deeper which makes them ideal communicators.

   D. ELF radio waves have larger speeds compared to UHF & VHF signals which make the communication smoother.

   Answer: C

4. When light is used in microscopy, the detail it can show is limited by its wavelength. What is the smallest detail visible by a light whose frequency is $1.5 \times 10^{15} Hz$?
A. $2.0 \times 10^{-7} nm$ B. $200nm$ C. $250nm$ D. We can't say for sure.
Answer: B

5. A radar is used to monitor the impacts on the surface of an asteroid nearby Earth. The asteroid is about $1.08 \times 10^{11} km$ away from Earth. How long does it take for a pulse emitted from the radar to reflect back to it?
A. 1 hour B. 100 hours C. 200 hours D. 3600 hours
Answer: C

6. A light ray is traveling through the interface between a glass and water emerging from the glass($n = \frac{8}{3}$) to water($n = 1.33$). Which of the following is true if the light was incident at an angle of 30^0, which of the following is true?

   A. The light ray bends towards the perpendicular to the interface.

   B. 30^0 is the critical angle for the light.

   C. If the angle of incidence was smaller than 30^0, the light ray would reflect back instead of refracting.

   D. The wavelength and the speed of the ray will decrease when entering water.

   Answer: B

7. Unlike other types of mirrors, the images formed by plane mirrors are
A. Virtual B. Right to left inverted C. Upright D. All
Answer: D

8. We have been describing electromagnetic waves as being self-propagating unlike other waves such sound. What do we mean by that?

   A. We mean that electromagnetic waves do not need medium to travel through because they have a special medium called the luminiferous ether to help them travel.

   B. We mean that electromagnetic waves are transverse disturbances while waves like sound are longitudinal.

   C. We mean that electromagnetic waves need media to travel through while other waves don't.

   D. We mean that electromagnetic waves don't need media to travel through because they are disturbances of electromagnetic fields themselves that travel away from source.

   Answer: D

9. γ rays and X rays are similar in the sense that both are very energetic, high frequency waves that usually offer similar applications. How are they different?

   A. X rays are formed only by the process of the bremsstrahlung while γ rays are only produced by thermal agitation.

   B. Although they have some overlapping frequency ranges, X rays generally have larger frequencies γ rays.

   C. X rays can be produced by electronic transition while γ rays usually require a nuclear process.

D. X rays and γ rays are identical except for their difference in frequency.

Answer: C

10. If you wish to detect details of the size of atoms (about $1A^0$) with electromagnetic radiation, which of the following electromagnetic waves would you use?
A. Visible light B. X rays C. Radio waves D. Infrared waves
Answer: B

11. Which of the following electromagnetic waves is usually radiated during the thermal agitation of matter?
A. Microwaves B. Visible light C. Infrared radiation D. γ rays
Answer: A/C

12. Which of the following is **most** refracted when light from the sun is passing through the atmosphere?
A. Violet visible light B. Blue visible light C. Infrared radiation D. Ultraviolet radiation
Answer: D

13. If there are two mirrors that are perpendicular to each other, what is the relationship between the incoming light ray and the outgoing reflected ray? They
A. are parallel B. are perpendicular C. cross each other at 45^0 D. diverge .
Answer: A

14. What is the speed of light in water($n = 1.33$)?
A. $4.0 \times 10^8 m/s$ B. $2.0 \times 10^8 m/s$ C. $2.25 \times 10^8 m/s$ D. $3.0 \times 10^8 m/s$
Answer: C

15. If a person is standing still in a swimming pool, their legs appear _____ when viewed from outside the pool.
A. longer B. shorter C. the same size D. invisible
Answer: B

Workout Problems

16. Calculate the ratio of the highest to lowest frequencies of electromagnetic waves the eye can see, given the wavelength range of visible light is from 450 nm to 760 nm. Would we be able to observe and study human cells which have an average diameter of about $100\mu m$? Why?

One of the frequencies is:

$$f = \frac{c}{\lambda}$$

$$f = \frac{3 \times 10^8 m/s}{450 \times 10^{-9} m} = 6.67 \times 10^{14} Hz$$

The other is:

$$f = \frac{c}{\lambda}$$

$$f = \frac{3 \times 10^8 m/s}{750 \times 10^{-9} m} = 4 \times 10^{14} Hz$$

The ratio can be calculated as follows;

$$\frac{6.67 \times 10^{14} Hz}{4 \times 10^{14} Hz} = \frac{6.67}{4}$$

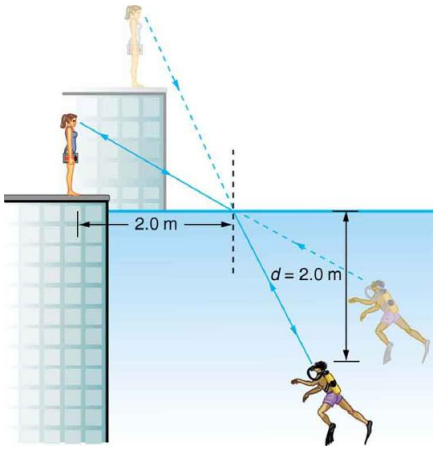
Another - a much simpler way - to calculate the ratio is relating the two frequencies as a function of their wavelengths:

$$\frac{f_1}{f_2} = \frac{\frac{c}{\lambda_1}}{\frac{c}{\lambda_2}}$$

$$\frac{f_1}{f_2} = \frac{\lambda_2}{\lambda_1}$$

$$\frac{f_1}{f_2} = \frac{750nm}{450nm} = \frac{750}{450} = \frac{15}{9} \approxeq \frac{6.67}{4}$$

17. A scuba diver training in a pool looks at his instructor. What angle does the ray from the instructor's face make with the perpendicular to the water at the point where the ray enters? The angle between the ray in the water and the perpendicular to the water is 30^0(The diver is at a depth of 2m below the surface of the water and the instructor is 2m away from the normal).



The angle given in the question is the angle of incidence. We are asked the angle of refraction. Despite the seemingly-intimidating nature of this question, it is quiet easy. We just have to use Snell's law.

$$n_1 \sin\theta_i = n_2 \sin\theta_r$$

Here, the first medium is water($n = \frac{4}{3}$) and the second medium is air($n = 1$).

$$\frac{4}{3} \sin 30^0 = (1) \sin\theta_r$$

$$\sin\theta = \frac{2}{3}$$

$$\theta = \arcsin\frac{2}{3}$$

18. Light traveling from water($n = 1.33$) to a some transparent stone strikes the surface at an incident angle of 60.0^0 and has an angle of refraction of 37.0^0.

- What is the speed of light in the stone?

  To answer this, we first need to find the refractive index of the stone. To do that, we use Snell's law. The first medium is water and the second medium is the stone and we have been given the angles of incidence and reflection.

$$n_1 \sin\theta_i = n_2 \sin\theta_r$$

$$(\frac{4}{3}) \sin 60^0 = n_2 \sin 37^0$$

$$(\frac{4}{3})\frac{\sqrt{3}}{2} = n_2(\frac{3}{5})$$

$$n_2 = \frac{10\sqrt{3}}{9}$$

  Now that we have the refractive index, we can work out the speed of light in this medium.

$$n = \frac{c}{v} \implies v = \frac{c}{n}$$

$$v = \frac{3 \times 10^8 m/s}{\frac{10\sqrt{3}}{9}}$$

- What is the critical angle if light was to travel from the stone to water?

$$\sin\theta_c = \frac{n_2}{n_1}$$

$$\theta_c = \arcsin\frac{n_2}{n_1}$$

$$\theta_c = \arcsin\frac{\frac{4}{3}}{\frac{10\sqrt{3}}{9}} = \arcsin\frac{6}{5\sqrt{3}}$$

19. During normal beating, the heart creates a maximum 4.00-mV potential across 0.350 m of a person's chest. If the EM wave created has a frequency of 7.00Hz,

- What is the maximum electric field strength created? We can find the electric field by using the voltage provided.

$$E = \frac{V}{d} = \frac{4 \times 10^{-3} V}{0.35m} = 1.14 \times 10^{-2} V/m$$

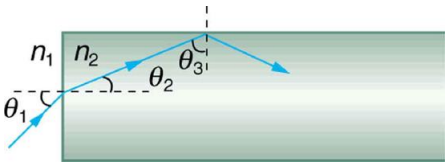
- What is the corresponding maximum magnetic field strength in the electromagnetic wave?

$$E = cB \implies B = \frac{E}{c} = \frac{1.14 \times 10^{-2} V/m}{3 \times 10^8 m/s}$$

$$B = 3.81 \times 10^{-11} T$$

Extra credit problems

20. A light ray entering an optical fiber surrounded by air is first refracted and then reflected as shown in the figure below. Show that if the fiber is made from crown glass($n = 1.52$), any incident ray will be totally internally reflected.



If the fiber is made of crown glass, the critical angle for the incident rays should be:

$$\sin\theta_c = \frac{1.0}{1.52}$$

$$\theta_c = \arcsin\frac{1.0}{1.52} = 41.14^0$$

For the incident ray to be totally internally reflected, $\theta_3 > 41.14^0$. Since

$$\theta_2 + \theta_3 = 90^0 \implies \theta_3 = 90^0 - \theta_2$$

. Thus,

$$90^0 - \theta_2 > 41.14^0$$

$$\theta_2 < 48.86^0$$

However, we know that for any θ_1 value, we can't have a θ_2 value of 48.86^0 because the highest value θ_2 can have is less than 41.14^0 and that is when $\theta_1 \approxeq 90^0$. Thus, any incident angle of θ_1 will result in a total internal reflection.