**Investigation 16**

**Electromagnetic Waves and Light**

1. Rank from highest frequency to lowest frequency the following electromagnetic waves:

**A**: infrared waves **B**: ultraviolet waves **C**: X-rays **D**: microwaves

 **C > B > A > D**

2. Why does light travel slower in air than in a vacuum?

 The extra time involved in being absorbed and reradiated by the atoms gives it a slower average speed compared to light in a vacuum that does not interact with anything.

In the following questions, draw the diagrams carefully. Do it accurately as you can.

 plane mirror

3. An object O is placed in front of a *plane* mirror. Two light rays are shown leaving the object and striking the mirror at points A and B. Draw the normal and the reflected rays at points A and B. Use the reflected rays to determine the position of the image of the object. What kind of image is this?

 nOrmal

 VIRTUAL

 IMAGE

NORMAL

 A

 O

 B

4. Two plane mirrors are placed in contact and make an angle of 90o with each other. A source of light O is placed in front of the mirrors. Draw the path a light ray takes that leaves the source, reflects from the top mirror, and then from the bottom mirror.

 top mirror

 bottom

 mirror

 O

5. An object O is placed in front of a *concave* mirror whose center of curvature is point C.. Two light rays are shown leaving the object and striking the mirror at points A and B. Draw the normal and the reflected rays at points A and B. Use the reflected rays to determine the position of the image of the object. What kind of image is this?

 REAL

 IMAGE

 A

 B

 O

 C

 O

 air A B C water

5. A light source in air, O, sends three light rays toward the surface of water. They hit the surface at points A, B, and C. Draw the normal at points A, B and C, and also draw the refracted rays.

6. A light source in water, O, sends three light rays toward the air-water boundary. They hit the surface at points A, B, and C. Draw the normal at points A, B and C, and also draw the refracted rays.

 air A B C

 water

 O

 cool air

 warm air

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7. The diagram shows plane wavefronts of light traveling to the right in air. They then encounter a region where the air is cooler above and warmer below. Draw how the wavefronts are deviated as they pass through this region. Why do they do that?

 LIGHT TRAVELS FASGTER THROUGH WARMER AIR BECAUSE THE MOLECULES ARE FURTHER APART AND THERE ARE FEWER INTEREACTIONS BETWEEN THE LIGHT AND THE MOLECULES.

8. A glass prism is shown with a beam of white light hitting the left side of the prism. Draw a normal where the white light hits the surface. From there, draw the path of the red and violet colored rays as they pass through the prism. Then draw normals where the rays hit the right side of the prism. Finally, draw the rays as they emerge and leave the right side of the prism.

glass prism

air

 white light

 RED

 VIOLET

9. A person observes a rainbow, as shown in the picture below. Draw rays of sunlight showing the path the sunlight takes from the sun to hit the raindrops that create the rainbow. Then draw the rays traveling from the rainbow to the observer’s eyes. Where must the sun be located in order for the observer to see a rainbow?

 SUN

 THE SUN MUST BE LOCATED BEHIND THE OBSERVER.

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