PHY 152/202: General Physics 2
Electricity, Magnetism and Light
Dec. 14, 2022 Final exam
No books, notes, or electronic devices
Exam, Form: A

Name: _____

Student Number: _____

TA: _____

Date: _____

Section 1. Matching of scientific terms and concepts (6 pts.)

_____ apt

_____ explication

_____ gypsum

_____ telegraph

_____ mica

_____ spectrum

_____ terrestrial

_____ analogous

_____ propagate

_____ meridian

_____ latent

_____ quicksilver

_____ agitate

_____ gross

_____ prism

_____ firmament

_____ galvanometer

_____ phenomena

_____ elucidate

_____ oscillation

_____ aqueous

_____ cogent

_____ veracity

_____ tourmaline

(a) analyze and develop (an idea) in detail

(b) an instrument for measuring electric current

(c) like water; watery

(d) a fact or situation that is observed to happen

(e) the entire range of wavelengths of electromagnetic radiation

(f) of, on, or relating to the earth

(g) liquid mercury

(h) appropriate or suitable in the circumstances

(i) conformity to facts; accuracy

(j) transmit through a medium

(k) the heavens or the sky

(l) comparable in certain respects

(m) a circle of constant longitude passing through a given place on the earth's surface

(n) a black or blackish mineral used to polarize light

(o) stir or disturb (especially a liquid) briskly

(p) make (something) clear; explain

(q) repetitive motion or vibration

(r) a shiny transparent silicate mineral with a layered structure

(s) a soft white or gray mineral consisting of hydrated calcium sulfate

(t) hidden; not manifest

(u) a triangular transparent object that separates light into separate of colors

(v) large-scale; not fine or detailed

(w) a system for transmitting messages from a distance along a wire

(x) (of an argument) clear, logical, and convincing

Section 2. Multiple choice (23 pts.)

1. Suppose that a ping pong ball is coated with metal foil and suspended by a thin copper thread from the grounded copper water pipes running across the ceiling of the laboratory. A glass tube, which has been rubbed with a bit of silk, is brought very near the ball without touching it. While the tube is near the ball, the copper thread suddenly breaks, and the ball falls toward the floor. What is the state of electrification of the ball while it is falling?

   (a) positively charged.
   (b) negatively charged.
   (c) neutral.
   (d) undetermined.

2. Two charges are separated by a distance D. If the distance is then doubled, the force acting upon each charge will be

   (a) quartered
   (b) halved
   (c) the same as before
   (d) doubled
   (e) quadrupled

3. An wire carries a large current, I, from south to north. When you hold a magnetic compass needle *above* the wire, the tip of the needle that initially pointed northward (toward canada) will now deflect

   (a) eastward
   (b) westward
   (c) all the way to the south
   (d) it will remain pointing northward
   (e) it will act like a motor, and just keep spinning around

4. Two parallel long wires carry the same current and repel each other with a force F per unit length. If both of these currents are tripled, and the separation between the wires is also tripled, then the force per unit length becomes:

   (a) F / 3
   (b) F
   (c) 3 F
   (d) 9 F
   (e) none of the above

5. A 1 kg ball is released and falls 5 meters to the ground. Based on the conservation of energy, the speed of the ball, upon striking the ground, is approximately

   (a) 1 m/s
   (b) 5 m/s
   (c) 2 m/s
   (d) 10 m/s
   (e) 100 m/s

6. When light slows down upon entering a medium, it bends towards the normal (to the interface). This
   (a) is known as Snell's law.
   (b) was first observed by Newton.
   (c) is only true for exotic materials, such as calcspar.
   (d) is evidence for the electromagnetic theory of light.
   (e) is false.

7. According to Christiaan Huygens, light is similar to sound in that it
   (a) obeys what is now known as Huygens' principle
   (b) needs a medium for propagation
   (c) consists of longitudinal waves
   (d) all of the above
   (e) none of the above

8. Iceland spar
   (a) is birefringent
   (b) was studied carefully by both Isaac Newton and Christian Huygens
   (c) naturally cleaves (or breaks) in the form of an oblique parallelpiped
   (d) was instrumental in understanding the transverse polarization of light
   (e) all of the above

9. When the slit spacing in a young's two-slit experiment is halved (all other things remaining equal), the separation between the interference fringes
   (a) is quartered
   (b) is halved
   (c) remains the same
   (d) is doubled
   (e) is quadrupled

10. In lab, you found that Brewster's angle for a block of glass is about how many degrees?
   (a) 35
   (b) 45
   (c) 55
   (d) 65
   (e) 75

11. A beam of white light falls upon a thin, uniform, film of soap ($n = 1.25$) suspended in the air. What is the (approximate) minimum thickness such that the film appears green ($\lambda = 500$ nm), when viewed from above?
   (a) 100 nm
   (b) 400 nm
   (c) 900 nm
   (d) 1300 nm
   (e) 1700 nm

12. Why does the sky appear bright blue overhead on a sunny day?

    (a) The atmosphere acts as a thin film which causes blue light to experience constructive interference.

    (b) Blue sunlight is scattered from the atmosphere more readily than other colors.

    (c) Blue light is refracted by the atmosphere more than other colors.

    (d) Light becomes polarized when scattering from the atmosphere.

    (e) The sky has blue dye in it.

13. Suppose that you stand on a chair and drop a bar magnet, north pole facing downward, into a small aluminum bucket below you. Just before the magnet enters the can, an electrical current is induced in the rim of the bucket

    (a) clockwise

    (b) counterclockwise

    (c) down the tube

    (d) up the tube

    (e) actually, no current is induced in the tube

14. A square loop of wire, 1 cm on a side, slides across a frictionless table, at a speed of 10 cm per sec. It enters a region in which there exists a downward pointing time-independent magnetic field whose strength is 1 mT. What is the magnitude of the electromotive force generated in the loop

    (a) 1 micro-volt

    (b) 10 micro-volt

    (c) 100 micro-volt

    (d) 1 millivolt

    (e) none of the above

15. An infrared light beam has a wavelength of about 10 micrometers. What is its frequency?

    (a) about 3×10^{13} Hertz

    (b) about 1×10^{13} Hertz

    (c) about 1×10^{11} Hertz

    (d) about 3×10^{8} Hertz

    (e) about 1×10^{6} Hertz

16. If we lived in a universe in which the permittivity of free space, ϵ_o, were four times as large, all other things being equal, the speed of light, as calculated by Maxwell, would have been

    (a) four times as large

    (b) twice as large

    (c) half as large

    (d) one-fourth as large

    (e) one-eighth as large

17. Fizeau found that, when propagating through flowing water, the speed of light is

    (a) a bit faster when traveling downstream than when traveling in stationary water

    (b) a bit faster when traveling upstream than when traveling in stationary water

    (c) the same as when traveling in stationary water

    (d) independent of the direction of travel

    (e) immeasurably fast

18. Consider a motorboat that is capable of traveling at a speed of three miles per hour in still water. What is the time required for this boat to go one mile upstream in a river flowing at a speed of one mile per hour.

    (a) less than twenty minutes

    (b) about half an hour

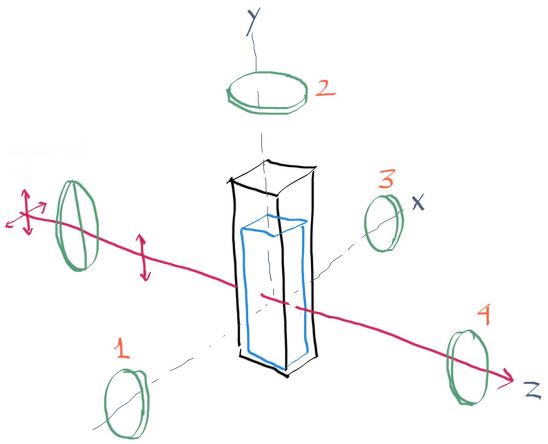
    (c) about an hour

    (d) about an hour and a half

    (e) about three hours

Section 3. Light scattering (4 pts.)

An initially unpolarized laser beam travels along the z-axis, as shown below. It passes through a polarizing filter that is oriented along the y-axis before striking a cuvette filled with a mixture of skim milk and water. The light scattered from the fluid can be viewed through polarizing filters at positions 1, 2, 3 and 4. Answer each of the following questions clearly.



1. If the polarizer at position 1 is oriented along the y-axis, will any scattered light be observed? What if it is rotated so it is oriented along the z-axis?

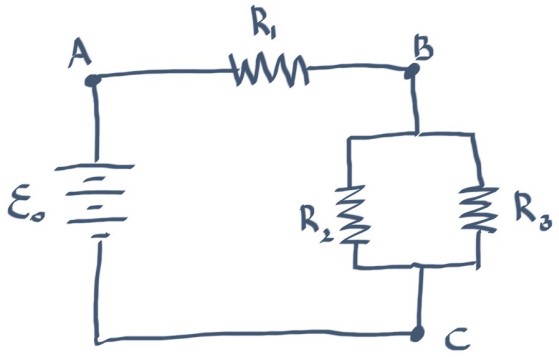
2. If the polarizer at position 2 is oriented along the x-axis, will any scattered light be observed? What if it is rotated so it is oriented along the z-axis?

3. If the polarizer at position 4 is oriented along the x-axis, will any scattered light be observed? What if it is rotated so it is oriented along the y-axis?

4. From which location, 1, 2, 3 or 4, is it a bad idea to observe the scattered light? Why?

Section 4. Electronic Circuit (4 pts.)

Consider the following electronic circuit. The power supply provides an electromotive force of $\varepsilon_0 = 10$ volts. The resistors have values $R_1 = 1$, $R_2 = 2$ and $R_3 = 6$ Ohms.



1. What is the equivalent resistance, R_p, of the two resistors in parallel?

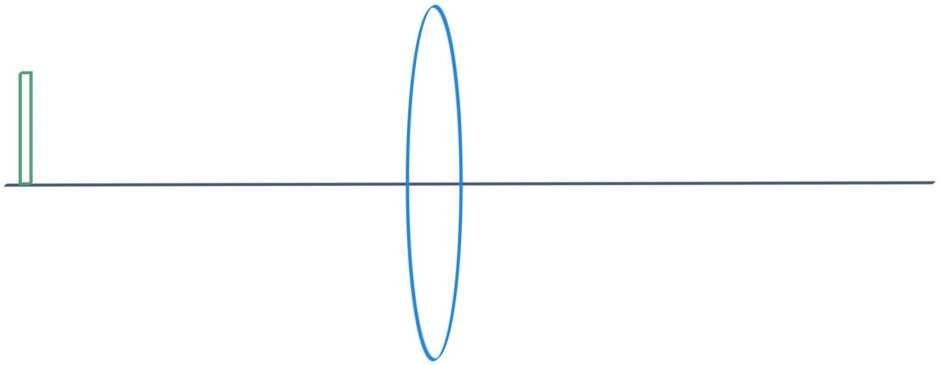
2. How much current is flowing through resistor R_1?

3. If the probes of a voltmeter were placed at positions B and C, what voltage would one measure between these points?

4. How many watts of heating power are being generated by resistor R_3?

Section 5. Optics (4pts.)

A green object, 1 cm tall, is placed 3 cm to the left of a double convex lens, as shown below. The focal length of the lens is 2 cm.



1. At what distance from the lens will the image be formed? Will it be to the right or to the left of the lens?

2. Will the image be upright or inverted? Make a sketch of the image at the proper location in the diagram.

3. Will the image be magnified? If so, by how much? In other words, what is the height of the image?

4. If the object were moved further to the left of the lens, would its image move toward or away from the lens? And if the object were moved very very far to the left, at what location would its image eventually be found?

Section 6. Maxwell's equations (PHY 202 students only, 4 pts.)

1. Write down Coulomb's law of electric force in vector form. Be sure to use correct vector notation.

2. From which of Maxwell's equations can Coulomb's law be derived? Write down this Maxwell's equation.

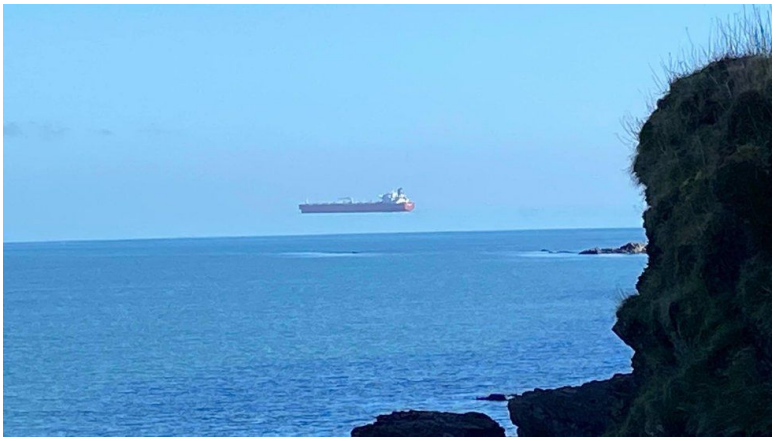
3. Which of Maxwell's equations imply that there are no magnetic monopoles? Write down this Maxwell's equation.

4. Which two of Maxwell's equations can be used to show that light is an electro-magnetic wave. Write down one of these equations.

Section 7. Short essay on action-at-a-distance and mediated action (2 pts.)

1. Explain clearly what is meant by the term "action-at-a-distance" and the term "mediated action." Also: give one example of "action-at-a-distance" and one example of "mediated action."

Section 8. Ghost ship (Extra credit 2 points)



1. The above photograph shows a ship that is apparently hovering above the surface of the water. What is going on here?