

PHY 152/202 , Fall 2021 Final Exam
Electricity, magnetism and light
Dec. 15, 8:00 - 9:45 a.m.
No books, notes, or electronic devices

Name: _____

Student Number: _____

TA: _____

Date: _____

Exam, Form: A

Section 1. Matching of scientific terms and concepts (13 pts.)

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| _____ fissile | (a) extending across (instead of along) something |
| _____ electromagnetic | (b) relating to electric and magnetic fields |
| _____ mutual | (c) the inference of particular instances from a general law |
| _____ apprehend | (d) in agreement or harmony with |
| _____ transverse | (e) relating to the perimeter of a curved figure |
| _____ galvanism | (f) transmission of electricity through something without movement of the material |
| _____ venture | (g) a driving or motivating force; an impetus |
| _____ circumferential | (h) following one another or following others |
| _____ consonant | (i) make (something) clear; explain |
| _____ agate | (j) having no limit |
| _____ rapidity | (k) quickness |
| _____ perceptible | (l) an ornamental stone; a variety of chalcedony |
| _____ conformity | (m) electricity produced by chemical action |
| _____ homogeneous | (n) about three miles |
| _____ fringe | (o) similarity in form or type |
| _____ deduction | (p) an instrument for measuring electric currents |
| _____ induction | (q) a risky or daring journey or undertaking |
| _____ infinitude | (r) able to be seen or noticed |
| _____ conduction | (s) able to be understood; comprehensible |
| _____ league | (t) reciprocal; complementary |
| _____ intelligible | (u) easily split |
| _____ constitution | (v) the composition of something |
| _____ elucidate | (w) consisting of parts all of the same kind |
| _____ successive | (x) a band of contrasting brightness or darkness produced by interference |
| _____ galvanometer | (y) the production of an electric or magnetic state from a nearby electrified or magnetized body |
| _____ impulse | (z) understand or perceive |

Section 2. Multiple choice (23 pts.)

1. A plastic rod is rubbed with fur. A small uncharged pith ball placed near the rod
 - (a) will be unaffected by the nearby rod.
 - (b) will be attracted to the rod because it has a net negative charge
 - (c) will be repelled from the rod because it has a net positive charge
 - (d) will be attracted to the rod because it becomes polarized by the nearby rod
 - (e) none of the above
2. Three positive one-coulomb charges are placed in a straight line. There is a one meter gap between each. The leftmost one has a charge of 1 coulomb. The middle one has a charge of 2 coulombs. The rightmost one has a charge of 3 coulombs. The coulomb constant is k . The middle charge feels a net force of
 - (a) $2k$ rightward
 - (b) $4k$ rightward
 - (c) $2k$ leftward
 - (d) $4k$ leftward
 - (e) $8k$ leftward
3. A straight copper wire carries an electrical current from east to west. When you hold a magnetized compass needle *above* the wire, the tip of a compass needle having a north magnetic polarity will point
 - (a) northward
 - (b) southward
 - (c) eastward
 - (d) westward
 - (e) the compass needle will retain whatever position it originally had
4. Suppose a large electrical current is traveling clockwise around the outer edge of this page. Also, suppose a strong magnetic field is pointing directly northwards. What would you have to do to keep the page from lifting off of the table?
 - (a) press down on the north edge of the page
 - (b) press down on the south edge of the page
 - (c) press down on the east edge of the page
 - (d) press down on the west edge of the page
 - (e) nothing
5. A 10 gram weight falls 20 meters. What is its speed just before striking the ground?
 - (a) 5 m/s
 - (b) 10 m/s
 - (c) 20 m/s
 - (d) 25 m/s
 - (e) 40 m/s

6. A light source in the form of a cross is placed 20 centimeters in front of a double convex lens. The lens has a focal length of 4 cm. A screen is placed behind the lens at a distance d . For a sharp image of the cross to form, the screen must be placed how far from the lens?
- (a) 4 cm
 - (b) 5 cm
 - (c) 10 cm
 - (d) 20 cm
 - (e) none of the above
7. According to Dutch scientist Christiaan Huygens, light is like 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. Standing at the side of a pool of water, you look down and see a coin a little way out at the bottom of the pool. The coin is
- (a) actually farther away than it appears
 - (b) actually closer than it appears
 - (c) just about exactly where it appears
9. When viewing distant stars near the horizon, atmospheric refraction causes them to appear
- (a) rounder than their actual shape
 - (b) higher than their actual location
 - (c) lower than their actual location
 - (d) bluer than their actual color
 - (e) larger than their actual size
10. 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 parallelepiped
 - (d) was instrumental in understanding the transverse polarization of light
 - (e) all of the above
11. A laser beam illuminates a thin fiber of hair, producing an interference pattern on a screen behind the hair. If the wavelength of the light is doubled, the spacing between the central bright fringe and the adjacent bright fringe will be
- (a) doubled
 - (b) halved
 - (c) quadrupled
 - (d) quartered
 - (e) remain the same

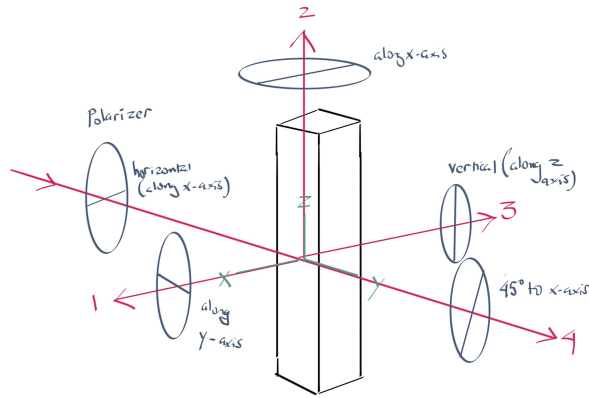
12. A thin soap film is stretched across the rim of a wine glass. When illuminated from above with white light, the color of the soap film very near the rim of the glass will appear
- (a) black
 - (b) reddish
 - (c) yellowish
 - (d) blueish
 - (e) white
13. Brewster's angle for a particular material is 60 degrees. The refractive index of this material is approximately
- (a) 2
 - (b) $\sqrt{3}$
 - (c) $\sqrt{3}/2$
 - (d) $\sqrt{2}$
 - (e) 1
14. A piece of mica is placed between two crossed polarizing filters. The mica is illuminated from one side and viewed through the polarizer on the other side. Different regions of the mica appear different colors. This is because
- (a) the incident light is white, so it contains several different wavelengths
 - (b) the differently colored regions of mica have different thicknesses
 - (c) mica is a birefringent material
 - (d) all of the above
 - (e) none of the above
15. Light of wavelength $\lambda = 600$ nm is incident upon the surface of a layer of material having a refractive index $n = 1.5$. If the angle of incidence is zero degrees, then how thick must the material be so that exactly three wavelengths fit inside the material?
- (a) 1800 nm
 - (b) 1200 nm
 - (c) 800 nm
 - (d) 600 nm
 - (e) none of the above
16. Why does the sky appear red at sunset?
- (a) The atmosphere acts as a thin film which causes blue light to experience constructive interference.
 - (b) Red sunlight is scattered from the atmosphere more readily than other colors.
 - (c) The red light becomes polarized when passing through the atmosphere.
 - (d) Red light is refracted by the atmosphere more than other colors.
 - (e) None of the above

17. Suppose that a one-gram bar magnet is dropped down a one meter long aluminum pipe. Its speed upon leaving the bottom is the same as the speed upon entering the top. About how much heat is generated in the aluminum pipe?
- (a) 0.01 Joules
 - (b) 0.1 Joules
 - (c) 1 Joules
 - (d) 10 Joules
 - (e) zero
18. A wire having radius R and length L connects the terminals of a battery. As a result, an electrical current I flows through the wire. How can the current be quadrupled?
- (a) quarter the radius
 - (b) quadruple the radius
 - (c) double the length
 - (d) halve the length
 - (e) none of the above
19. A beam of positively charged atoms passes across the face of a bar magnet. Suppose the north pole of the magnet faces upwards. The beam travels eastward. The beam of atoms is deflected
- (a) northward
 - (b) southward
 - (c) westward
 - (d) upward
 - (e) downward
20. **In this question, you should circle all of the answers that apply.** A circular loop of conducting wire slides westward across a frictionless table. A magnet is placed underneath the table with its south pole facing upward and its north pole facing downward. As the loop slides towards the magnet,
- (a) a current is induced in the clockwise direction (as viewed from above)
 - (b) a current is induced in the counter-clockwise direction (as viewed from above)
 - (c) it speeds up
 - (d) it slows down
 - (e) it retains the same speed
21. A hemispherical glass lens is placed, flat side up, atop a plate of glass. It is illuminated with a red light from above. The ring-shaped interference fringes that are produced
- (a) retain the same position and spacing when the lens is pressed downwards with a heavy weight
 - (b) are more closely spaced at the periphery of the lens than at the middle of the lens
 - (c) are more widely spaced at the periphery of the lens than at the middle
 - (d) are produced only when the lens is constructed of birefringent material
 - (e) disappear entirely when the red light is exchanged for a green light

22. Suppose, when calculating the speed of light based on your laboratory experiments, that you over-estimated the magnetic permeability of space (μ_0) by a factor of 9 (everything else remaining the same). Then your calculation of the speed of light would have been
- (a) over-estimated by a factor of 9
 - (b) under-estimated by a factor of 9
 - (c) over-estimated by a factor of 3
 - (d) under-estimated by a factor of 3
 - (e) unaffected.
23. Michelson and Morley attempted to measure the speed of the Earth as it travelled through the aether that (supposedly) filled space. In the process,
- (a) they found that the speed of light in different directions in their laboratory was, in fact, the same.
 - (b) they concluded, based on their experiments, that the aether must not exist.
 - (c) they discovered that light was, in fact, a particle and not a wave.
 - (d) All of the above.
 - (e) None of the above.

Section 3. Scattering of laser light (6 pts.)

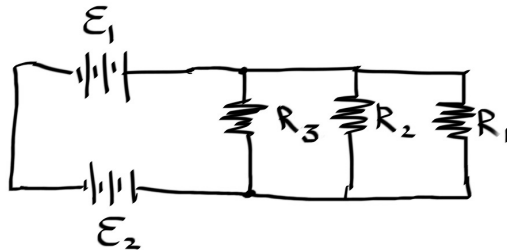
An initially unpolarized laser beam travels along the y-axis, passes through a horizontal polarizing filter (as shown below), and strikes a mixture of skim milk and water inside a glass cuvette.



1. First, clearly state whether any scattered light is observed at each of the four positions (1, 2, 3, and 4) when viewed through the polarizers that are oriented as shown. For each location just say yes (scattered light is observed) or no (scattered light is not observed). Assume that the polarizers work perfectly well.
2. If the polarizer in the initial beam path is removed, then is any scattered light observed through the polarizers at positions 1, 2, 3 and 4?
3. Finally, suppose that the light striking the cuvette consists of vertically and horizontally polarized components that are equal in amplitude but are exactly 180 degrees out of phase with one another. In particular: when the x-polarized component is at a maximum, the z-polarized ray is at a minimum. Is any scattered light observed through the polarizers at positions 1, 2, 3 and 4?

Section 4. Electronic circuit analysis (10 pts.)

Consider the following electronic circuit, which contains two batteries whose negative terminals are wired together (so the negative terminals are at the same electric potential). The three resistors between the positive terminals are connected in parallel with one another. The batteries have electric potentials $\varepsilon_1 = 12$ and $\varepsilon_2 = 9$ volts, respectively. The resistors have values $R_1 = 2$, $R_2 = 4$ and $R_3 = 4$ Ohms.



1. Find the amount of electric current flowing through each of the three resistors. Draw an arrow indicating the direction of the current through each resistor. Hint: remember your circuit rules!

2. How many watts of heating power are being generated by each of the three resistors?

3. As the resistors heats up, does the electrical current passing through them increase, decrease, or remain constant? Explain your answer.

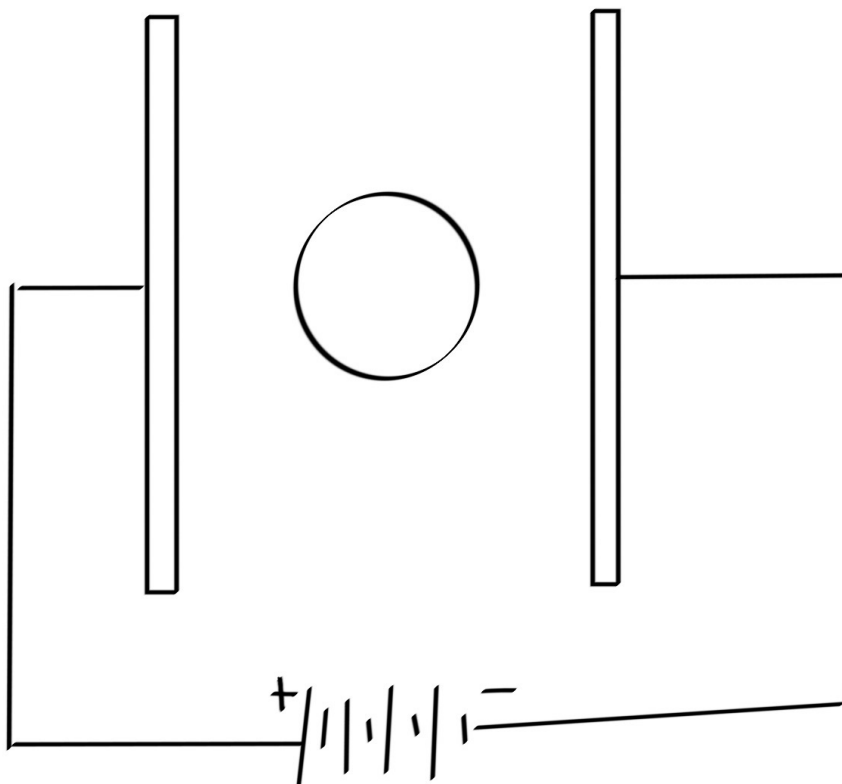
Section 5. **PHY 152 students only:** Electric and Magnetic Field mapping (8pts.)

In each of the following diagrams, sketch the electric or the magnetic field (whichever is appropriate). You will be scored on the clarity of your drawing. In each case, be sure to use arrows to indicate the direction of the fields.

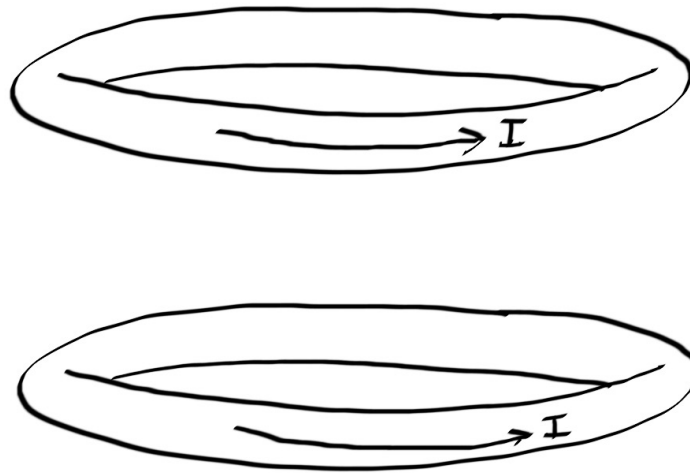
1. Two oppositely charged spheres.



2. Conducting sphere between two charged capacitor plates.



3. Two electrical current loops



4. Two iron cubes in front of a bar magnet.

