Science-1A Lecture: Week-8, Monday, September 27, 2021

Quiz-4 is the final quiz before the Physics Midterm.
Make sure you catch up on any missed quizzes during the next two weeks!

Quiz-4 is next week, so today I will go over the Example Questions for Quiz 4 and their solutions. These are at *https://yosemitefoothills.com/Science-1A/QuizAndTestPractice/SampleQuestions-Quiz-4.pdf* and *https://yosemitefoothills.com/Science-1A/QuizAndTestPractice/SampleQuestions-Quiz-4-Solutions.pdf* .

See the boxed note at the start of the Week-2 Monday lecture at *https://yosemitefoothills.com/Science-1A/OnlineLectureAndLabNotes/Week-02-Lecture-Monday-August-16-2021.pdf* for an explanation of the Equation Sheet and its use.

The following discussion is long, but I needed to try an anticipate the points of confusion that I easily clarify during a spoken lecture. **Study this note carefully because you must do the work without any reference to this note while taking Quiz 4.** Only a clean Equation sheet is to be used when taking the Quizzes and Tests.

The calculation answer style shown in the solutions sheet is the style that should be followed when writing calculation solutions. I will be fussy about writing the starting equation, and if required, alterations to it. Also, the setup should have proper mathematical form and values should be written with their units using parentheses if appropriate. The final answer should have 3 or 4 significant figures unless more are requested, and of course, answers should have the correct units.

This quiz has few calculations questions, but don't take it lightly. The calculation questions allowed more opportunities for partial credit than do fill-in-the-blank and true-false questions. Understanding the logic behind the questions and answers is more effective than just trying to memorize answers. Understanding science is largely a matter of knowing the vocabulary of science, so many questions are about the special words used in physics. Also, remember, the questions on the quizzes and tests may look like the practice questions, but may have wording changes that require you to read carefully and think!

Don't freak out because there are 51 possible questions. Most are very easy if you followed the lecture and Lab notes.

Question 1: (2 points) Opposite charges (**attract**, ~~repel~~) and like charges (~~attract~~, **repel**).

Just remember the expression "opposites attract". That applies to opposite charges and to opposite magnetic poles. Be sure to read the question carefully since a quiz or test question may be worded differently.

Question 2: (2 points) The force between charges is (**directly**, ~~inversely~~) proportional to the charges and (~~directly~~, **inversely**) proportional to the square of their separation. This is called Coulomb's Law and is very much like Newton's Law of Gravitation except that charges can be positive and negative while masses are always positive.

The formula for Coulomb's Law is near the top of page 3 of the Equation Sheet. Looking at it tells you how to answer this question since you know what "directly proportional" and "inversely proportional" mean from a discussion at the very start of this course.

Question 3: (1 points) An electron has a (~~positive~~, **negative**) charge.

This you just have to remember. We write electrons with the symbol e^- to show that it is negative.

Question 4: (1 points) The nuclei of atoms have a (**positive**, ~~negative~~) charge.

We have not yet studied atoms, but you should have picked up from earlier schooling that atoms have a nucleus surrounded by a bunch of electrons. In order for the negatively-charged electrons to stay near the nucleus, the nucleus must have a positive charge.

Question 5: (2 points) Some objects hold on to their electrons more strongly than others so rubbing two different objects together is one way to create an electric __**charge**__ difference.

Think of generating a spark by walking across a synthetic fiber rug with rubber-soled shoes. Or taking off a T-shirt on a night of low humidity. The electrons are moved between your hair and the shirt leading to a great light show in the dark.

Question 6: (2 points) When water breaks into droplets, the droplets are likely to have unbalanced **charges**.

With about 10^{22} electrons in a water droplet, it would be highly unlikely that all water molecules would exactly retain their full set of electrons when breaking off from a water stream.

Question 7: (2 points) Charges are surround by an **electric** field.

This you just need to remember.

Question 8: (2 points) Electric field lines start at (**positive**, ~~negative~~) charges and end at (~~positive~~, **negative**) charges. (In either case, those charges might be located so far away they are considered to be at infinity.)

This is just a tradition, but it fits in with the idea that the electric field lines show how a positive test charge would move. Since a positive test charge would be pushed away from fixed positive charge, the electric field lines of the fixed positive charge point away it. The positive test charge would be pulled toward a fixed negative charge, so the electric field lines point toward negative charges.

Question 9: (2 point) Like magnetic poles (~~attract~~, **repel**) each other while unlike poles (**attract**, ~~repel~~) each other.

This is just the magnetic version of Question 1 – opposites (unlike poles) attract, like poles repel.

Question 10: (1 points) When magnets are divided, one can have separate north and south poles. (~~true~~, **false**)

This seems reasonable, but it is not true. When a magnet is divided, you end up with two magnets, each with a north and south pole. Nature does not allow separate magnetic poles even though physicists have theorized about them and searched for them, no separate magnetic poles have been seen by any experiment.

Question 11: (1 points) The north geographic pole of the earth is near its north magnetic pole. (~~true~~, **false**)

The **north** pole of a compass needle points toward Greenland which is near the north **geographic** pole. But that means that the **south magnetic pole of the earth** must be near Greenland since north and south magnetic poles attract. The north magnetic pole of the Earth is in Antarctica and pulls on the south pole of the compass needle.

Question 12: (1 points) Magnetic field lines always form closed loops. (**true**, ~~false~~)

Magnetic field lines go from north to south poles of a magnet. They complete their loop inside the magnet ending up back at the north pole. Since there can never be separate north and south poles, the magnetic field lines must form closed loops. This is different from electric fields where charges do not need to come in matched pairs.

Question 13: (1 points) Magnetic north and south poles always come in matched pairs. (**true**, ~~false~~)

This is just a variation on Question 10 so the answer must be true.

Question 14: (1 points) A “conventional current” is one flowing from (**positive to negative**, ~~negative to positive~~) contacts.

Think of the "positive test charge" mentioned in Question 8. Conventional current is in the direction positive charges would be flowing even though the wire might actually be carrying negative electrons in the opposite direction. The definition of current direction was decided before electrons were discovered.

Question 15: (2 points) A wire carrying an electric current produces **magnetic** field rings around it.

You saw this in a video in the lecture for Friday, September 17. It was also discussed in the lab for Wednesday, September 15. It is a fact that allows us to make electromagnets.

Question 16: (2 points) Certain materials like iron have microscopic magnetic clusters called __**domains**__.

We discussed this in the lab for Wednesday, September 15. The alignment of the magnetic domains in the steel core is what helped our magnetic levitation demonstration work much better. This is a vocabulary word you need to know.

Question 17: (2 points) A charge in an electric field feels a __**force**__ proportional to the size of the charge and the strength of the electric field.

Electric fields were topic of a Crash Course (CC 26) watched as part of the lab of Wednesday, September 8. You might also remember the discussion on Wednesday, September 15 of how a Tesla Coil creates an electric field that stirs the electrons in a fluorescent tube without any wires connected. Or how electromagnetic field waves move electrons in antennas as discussed at the end of the lecture of Monday, September 20.

Question 18: (2 points) In the presence of the magnetic field from a wire coil wound around an iron core, the randomly oriented __**domains**__ in the iron become aligned and produce an enhanced magnetic field.

Just like in Question 16, this checks if you remember about how magnetic domains help strengthen electromagnets.

Question 19: (4 points) A moving magnet produces a/an __**electric**__ field around it which can move __**electrons**__ in a wire coil thereby producing an electric __**current**__ which then produces an opposing __**magnetic**__ field.

In the lab of Wednesday, September 15, we read about how a magnet moving inside of a solenoid caused an electric field in the solenoid wire. That electric field pushed electrons through a connected galvanometer producing an electric current. That current produced an opposing magnetic field, but it was too weak to be noticeable.

That demonstration was followed by an equivalent demonstration where a large electromagnet was energized by a car battery. It produced an opposing magnetic field in a hanging aluminum ring (a one-turn "coil") that pushed away from or pulled toward the large electromagnet.

Question 20: (4 points) A changing magnetic field produces a/an __**electric**__ field around it which can move __**electrons**__ in a wire coil thereby producing an electric __**current**__ which then produces an opposing __**magnetic**__ field.

The physics is the same as in the previous question. It does not matter whether the changing magnetic field was caused by a moving magnet or from an electromagnet being energized or de-energized.

Question 21: (2 points) Charges moving in a magnetic field feel a __**sideways**__ force proportional to their velocity and to the magnetic field strength.

During the description of the stirring of electrons in an aluminum plate by a moving magnet (lab of September 15), it was mentioned that they moved because they felt a sideways force. In the lab, I usually also demonstrate that effect using an oscilloscope which is like an old-fashioned television set with an electron gun at the back sending an electron beam to a phosphor screen at the front. Moving a magnet in front of that screen easily shows how the electron beam is deflected sideways. It does not matter whether the electrons are moving or the magnet is moving; it is their relative motion that matters.

Question 22: (2 points) A changing electric field produces a changing __**magnetic**__ field around it. This is very difficult to demonstrate directly, but makes electromagnetic waves possible.

There are many easy demonstrations of how a changing magnetic field can produce an electric field effect, but the reverse where a changing electric field generates a magnetic field, is too weak to demonstrate in an analogous manner.

When Maxwell assumed that such an effect might exist, he produced equations for electromagnetism that allowed for the existence of electromagnetic waves. That we have radio and light is actually proof that changing electric fields do indeed produce changing magnetic fields.

Question 23: (2 points) Electromagnetic waves travel at the speed of __**light**__.

That is because light is an electromagnetic wave, and electromagnetic waves of different frequencies all travel at the speed of light.

Question 24: (14 points; this has too many points for a quiz, but might appear on a test!) Fill in the blanks in the following two paragraphs with the correct words chosen from the following list: **negative negatively positive positively top bottom moist sun updraft downdraft**

The ___**sun**____ heats some parts of the earth more than other parts causing an __**updraft**___ which carries __**moist**__ air up to high altitudes where it condenses forming thunderclouds. Within the clouds charges become separated and _**positively**_charged lighter ice crystals or water droplets are carried to the ___**top**___ of the cloud. _**negatively**_ charged heavier ice crystals or water droplets accumulate near the __**bottom**__ of the clouds.

The earth is _**negatively**_ charged, but less so than the __**bottom**__ of the clouds setting the conditions for lightning which will allow a _**negative**__ current flow from the _**bottom**__ of the cloud to the earth.

The _**positive**___ charges at the ___**top**___ of the clouds spread through a wide region distant from the thunderstorm and cause the "fair weather electric field" of 100 V/m. That electric field causes a _**positive**__ current from the upper atmosphere to flow to the earth completing the atmospheric electric current loop.

It should help to review note about "Soaring Birds, ..." at *https://yosemitefoothills.com/Science-1A/Handouts/Week-06/AtmosphericElectricity.pdf* .
It should be easier to remember what words to fill in if you follow the logic of this text. (I am not going to be fussy about mixing up positive with positively, or negative with negatively, but don't mix up positive and negative or top and bottom.) This question is worth a lot of points. Be ready to see it on a Midterm or Final.

Question 25: (1 points) In the water dropper demonstration, the aluminum foils pulled together because they had (~~the same~~, **opposite**) charges.

Opposite charges attract.

Question 26: (1 points) A capacitor is two pieces of metal that have (~~the same~~, **opposite**) charges.

We charge a capacitor by putting a battery's positive terminal to one side of the capacitor and negative terminal to the other. That places opposite charges on the two sides of the capacitor and stores electric energy in the capacitor.

Question 27: (4 points) An ideal transformer with 100 turns in its primary winding and 500 turns in its secondary winding is connected to 120 VAC. How much voltage will appear in its secondary winding?

$$\frac{(\textbf{primary voltage})}{(\textbf{primary loops})}=\frac{(\textbf{secondary voltage})}{(\textbf{secondary loops})} \quad \textbf{or} \quad \frac{V_p}{N_p}=\frac{V_s}{N_s} \quad \textbf{so} \quad V_s=\frac{N_s}{N_p}V_p=\frac{\textbf{500 turns}}{\textbf{100 turns}}\cdot\textbf{120 V}=\textbf{600 V}$$

Transformers were discussed at the end of the lab notes for September 15 and in Crash Course 35 linked to in the lecture of September 17. The formula is at the end of the Chapter 6 section on page 3 of the Equation Sheet. Read the question carefully so that you correctly identify N_p, N_s, and V_p. Remember, if the secondary coil has fewer turns the voltage will be lower and it can supply more current; if it has more turns the voltage will be higher and it can supply less current. A transformer must obey the laws of thermodynamics so it cannot increase power, which is the product of voltage and current.

Question 28: (4 points) An ideal transformer with 100 turns in its primary winding and 5 turns in its secondary winding is connected to 120 VAC. How much voltage will appear in its secondary winding?

$$\frac{(\textbf{primary voltage})}{(\textbf{primary loops})}=\frac{(\textbf{secondary voltage})}{(\textbf{secondary loops})} \quad \textbf{or} \quad \frac{V_p}{N_p}=\frac{V_s}{N_s} \quad \textbf{so} \quad V_s=\frac{N_s}{N_p}V_p=\frac{5\,\textbf{turns}}{100\,\textbf{turns}}\cdot 120\,\textbf{V}=6\,\textbf{V}$$

The comments to Question 27 apply here as well.

Question 29: (1 points) An ideal transformer can provide more power at its output than is delivered to its input. (~~true~~, **false**)

A transformer is a passive device with no internal source of energy so it cannot provide more power at its output (secondary) than it receives at its input (primary).

Question 30: (1 point) When a bar magnet is resting inside of a coil, no electric current is produced. (**true**, ~~false~~)

This was demonstrated in demonstration 2 of the lab of Wednesday, September 15. Only **changing** magnetic fields generate electric fields and therefore electric currents. Electric effects result only if a magnet is moving with respect to a wire (coil), a wire (coil) is moving with respect to a magnet, or a magnet is changing its strength.

Question 31: (1 point) Moving a magnet near a wire coil is one way of generating an electric field and therefore an electric current. (**true**, ~~false~~)

A moving magnet near a wire coil produces a changing magnetic field at the coil. That changing magnetic field then produces electric fields and therefore can cause the flow of electric current.

Questions 32-38: These check if you know the different names for electromagnetic waves of different frequencies. Studying the color picture of the electromagnetic spectrum at
https://yosemitefoothills.com/Science-1A/Handouts/Week-07/Electromagnetic-spectrum.png
shows this with the different names given. The only waves in these questions that are **not** electromagnetic waves are sound and water waves.

Question 39: (4 points) An electromagnetic wave has a frequency of 10^{14} Hz. What is its wavelength?

$$c=\lambda f \quad \textbf{so} \quad \lambda=\frac{c}{f}=\frac{299792458\,\textbf{m/s}}{10^{14}\,\textbf{Hz}}\approx\frac{3.00\times10^{8}\,\textbf{m/s}}{10^{14}\,\textbf{Hz}}\approx 3.00\times10^{-6}\,\textbf{m}\approx 3.00\,\mu\,\textbf{m}$$

The necessary starting formula for questions involving wavelength λ of electromagnetic waves is on the second line of the Chapter 7 section on page 3 of the Equation Sheet. It uses the speed of light which for our purposes can be approximated by $c=3.00\times10^{8}\,\text{m/s}$. (The same formula, but with a different speed is used for sound.) Remember that the frequency unit Hz is the same as 1/s so (m/s)/Hz = (m/s)/(1/s) = m. Be careful to notice any unit prefixes that might be used when the frequency is given in this question!

Question 40: (4 points) An electromagnetic wave has a wavelength of 1.00 m. What is its frequency?

$$c=\lambda f \quad \textbf{so} \quad f=\frac{c}{\lambda}\approx\frac{3.00\times10^{8}\,\textbf{m/s}}{1.00\,\textbf{m}}\approx 3\times10^{8}\,\textbf{Hz}\approx 300\,\textbf{MHz}$$

This is just an alternate form of Question 39. Here the wavelength is given and the frequency is requested. Be careful to notice any unit prefixes that might be used when the wavelength is given in this question!

Question 41: (2 points) Microscopes and telescopes both are limited by (**diffraction**, ~~reflection~~, ~~refraction~~) of light.

Recall that light passing through a hole produces diffraction rings. This was easily seen for laser light, but it is true for all light. The light from stars seen with telescopes and that from bacteria seen with microscopes both must pass through holes. That might be a huge 5 m diameter opening in a large telescope or the 3 mm opening in a microscope. Diffraction rings limit the sharpness of the images in both devices.

Question 42: (1 points) In a pinhole camera and our eyes, the image is (~~right-side up~~, **upside down**).

Study the pinhole camera illustration at
https://yosemitefoothills.com/Science-1A/Handouts/Week-07/PinholeAndLensOpticalSystems.png
to see how the image ends up being upside down. Even though this is also true for our eyes, our brain flips it to give us the illusion of a right-side up view.

Question 43: (2 points) Normal human eyes can adjust their focus from (~~0.1~~, **0.25**, ~~0.5~~, ~~1.0~~) m to infinity.

You just need to remember this. If your eyes have 20/20 vision, you could look at a page and move it closer to your eyes until it becomes blurred at closer than about 0.25 m.

Question 44: (1 point) Light is electric and magnetic fields pulling each other through space. (**true**, ~~false~~)

This was explained on page 3 of the lecture notes for Monday, September 20.

Question 45: (2 points) When hot objects emit light it is called __**blackbody**__ radiation.

Blackbody radiation was discussed (without calling it that) on page 1 of the lecture notes for September 6. It was also discussed in Crash Course 43 about Quantum Mechanics referenced on page 3 of the lecture on September 24. Shiny objects also emit (or absorb) blackbody radiation, but with far less efficiency than pure "black" objects. What is "black" depends on the light frequency. Glass is "black" to infrared rays, but transparent to visible light. An ice cube is an efficient "blackbody" emitter even though it doesn't look black in visible light.

Question 46: (1 point) A smooth surface produces (~~diffuse~~, **specular**) reflection of light.

When light strikes an object, it can be reflected like off a mirror (specular reflection), or bounce off in a wide range of directions (diffuse reflection) like off a piece of paper. The difference between those is the roughness of their surfaces. If a surface is smooth at the scale of a wavelength of light (0.5 microns), it will reflect light like a mirror, but if it is rougher than that each bump in the surface will bounce the light in a different direction. Imagine a ball bouncing off a smooth concrete surface compared to one bouncing off bumpy ground.

Question 47: (1 point) A rough surface produces (**diffuse**, ~~specular~~) reflection of light.

This is just a variation of Question 46 so look at its explanation.

Question 48: (1 points) Light travels (**faster**, ~~slower~~) in warm air than in cold air.

This was discussed on page 1 of the lab notes for September 22 in connection with mirages. Light travels faster in hot air because its molecules are farther apart than in cold air and therefore slow down the light less from its natural speed in a vacuum. (Sound travels faster in hot air because the air molecules carrying the sound are moving faster.)

Question 49: (2 points) When we see the sun at the horizon, it is actually (~~above~~, **below**, ~~at~~) the horizon.

This was explained on page 1 of the lab notes for September 22 using Fermat's Principle.

Question 50: (1 point) Sunsets and sunrises are reddish because the blue colors have been scattered to land beyond the horizon leaving only the reddish light for us to see. (**true**, ~~false~~)

This and the next question are true as explained on page 2 of the lab notes for September 22. Air scatters blue light more than red so sunlight makes our sky blue during the middle of the day, but gives us red sunsets and sunrises. During our red sunset (ignoring smog and fire smoke effects) we are getting the red light left over after the blue light has been scattered to Hawaiians and the waters of the Pacific Ocean.

Question 51: (1 point) The sky (away from the sun) is blue because the atmosphere above us scatters the blue light toward us letting reddish light go elsewhere. (**true**, ~~false~~)

See the explanation after Question 50.