St John Baptist De La Salle Catholic School, Addis Ababa

Final Examination Preparation Problems

4th Quarter

June, 2022

Useful Constants

- $\mathbf{e} = 1.6 \times 10^{-19}$C - elementary charge $\mathbf{m}_e = 9.11 \times 10^{-31}$kg - mass of an electron
- $\mathbf{m}_p = 1.673 \times 10^{-27}$kg - mass of a proton $\mu_0 = 4\pi \times 10^{-7} \frac{H}{m}$ - permeability of free space
- $\epsilon_0 = 8.85 \times 10^{-12} \frac{F}{m}$ - permitivitty of free space $\mathbf{G} = 6.672 \times 10^{-12} \frac{Nm^2}{kg^2}$ - gravitational constant
- $\mathbf{N}_A = 6.022 \times 10^{23} \frac{1}{mol}$ - Avogadro's number $\mathbf{a}_g = 10 m/s^2$ - acceleration due to gravity
- $\textbf{sin } 60^0 = \textbf{cos } 30^0 = \frac{\sqrt{3}}{2}$ **AND** $\textbf{sin } 30^0 = \textbf{cos } 60^0 = \frac{1}{2}$
- $\textbf{sin } 37^0 = \textbf{cos } 53^0 = 0.6$ **AND** $\textbf{sin } 53^0 = \textbf{cos } 37^0 = 0.8$
- $\textbf{sin } 45^0 = \textbf{cos } 45^0 = \frac{\sqrt{2}}{2}$ **AND** $\textbf{sin } 90^0 = \textbf{cos } 0^0 = 1$ **AND** $\textbf{sin } 0^0 = \textbf{cos } 90^0 = 0$

Prroblems

1. The scattering of light rays when it encounters a tiny passage is called: <u>diffraction</u>
2. What is the reasoning behind Lenz's law?

   The law of conservation of energy is the primary reason behind Lenz's Law.
3. State the difference between half-wave and full-wave rectifications and how they occur.

   Half wave rectification happens when we use a single diode to rectify AC current. We call it half-wave rectification because just half of the cycle gets rectified during the forward bias and the other half doesn't during reverse bias. For a full-wave rectification, one of the most common ways to achieve it is using a bridge rectifier and it is call full-wave because the whole wave/signal(not just part of it) gets rectified.
4. State the properties of images created by plane, converging and diverging mirrors and their notable properties.

   Plane Mirror

   - Image is always upright
   - Image is always virtual
   - Image is laterally inverted(right to left)

   Concave/Converging Mirror

- Image is magnified and virtual when close to the mirror(closer than the focal point).
- Image is real and diminished when away from the mirror(beyond focal point).

Convex/diverging Mirror

- Image is always virtual, diminished and upright.

5. A generator supplies 120V to the primary coil of a transformer. The primary has 40 turns and the secondary has 800 turns. What is the secondary voltage?

$$\frac{N_s}{N_p} = \frac{V_s}{V_p}$$

$$V_s = V_p \frac{N_s}{N_p} = 120V \times \frac{800}{40}$$

$$V_s = 2400V = 2.4KV$$

6. An object stands erect 20cm from a converging mirror of focal length 40cm. How far apart are the pin and its image?

   First, we need to find the distance of the image from the mirror. To do that, we need to use the mirror equation:

$$\frac{1}{S_i} + \frac{1}{S_o} = \frac{1}{f}$$

$$\frac{1}{S_i} = -\frac{1}{S_o} + \frac{1}{f}$$

$$\frac{1}{S_i} = \frac{1}{40cm} - \frac{1}{20cm}$$

$$\frac{1}{S_i} = \frac{1-2}{40cm} = \frac{-1}{40cm}$$

$$S_i = -40cm$$

   We get the distance of the image to be -40cm. That means there is a distance of 60 cm(*20 cm-(-40cm)*) between the object and its image.

7. A long solenoid has 5000 turns uniformly distributed over a length of 0.50m. What current is required in the windings to produce a magnetic field of $\pi \times 10^{-2}$T at the center of the solenoid?

$$B = \mu_0 n I$$

$$I = \frac{B}{\mu_o n}$$

$$n = \frac{N}{L} = \frac{5000}{0.5m} = 10000/m$$

$$I = \frac{\pi \times 10^{-2} T}{4\pi \times 10^{-7} H/m \times 10^4/m} = \frac{10^{-2+3} T m^2}{4H}$$

$$I = 2.5A$$

8. We saw quantities being expressed in units of MWh(Mega-Watt hour), what physical quantity does the unit represent?

   1 Mega-Watt hour is basically 10^6 Watt multiplied by 3600 seconds which yields 3.6×10^9J which is a unit of energy.

9. An input of direct current is sent into an unknown electrical device and when current emerges out of the device, the output current is alternating. What device could the unknown be?

   If the input current is direct and the output is alternating we know that our unknown device changes DC current to AC and one device that we know does this job is an inverter.

10. What is the inductive time constant of a circuit with a resistance of 400K$\Omega\Omega$ and L=220mH?

    The inductive time constant of a circuit is given by:

$$\tau_L = \frac{L}{R}$$

$$\tau_L = \frac{220 \times 10^{-3} H}{400 \times 10^{3} \Omega}$$

$$\tau_L = 5.5 \times 10^{-7} s$$

11. What is magnetic flux density and what is its SI unit?

    Magnetic flux density or the magnetic field strength is the density of magnetic field lines in a given area. It is mathematically given by:

$$B = \frac{Flux}{Area} \text{ with units of } \frac{Wb}{m^2} \text{ or Tesla}$$

12. Why is doping important when dealing with semi-conductors?

    Doping is important to increase the conductivity of semiconductors(or decrease their resistivity).

13. What is thermionic emission?

    Thermionic emission is the ejection of electrons from the hot metal in Fermi valves. It indicates the emission of electrons as a result of heating.

14. The period of a transverse electromagnetic wave is 0.06s, what is its frequency?

$$\mathrm{f} = \frac{1}{T}$$

$$\mathrm{f} = \frac{1}{6 \times 10^{-2} s}$$

$$\mathrm{f} = 1.67 \times 10^{3} \mathrm{Hz}$$

15. If a mirror produces a real image that is four times as large as the object and the object is located 50cm from the mirror, what is the focal length of the mirror?

$$\mathrm{M} = \frac{h_i}{h_o} = -\frac{S_i}{S_o}$$

$$4 = -\frac{S_i}{S_o}$$

$$S_i = -4S_o$$

$$S_i = -4 \times 50cm = -200cm$$

$$\frac{1}{f} = \frac{1}{S_i} + \frac{1}{S_o}$$
$$\frac{1}{f} = \frac{1}{50cm} + \frac{-1}{200cm}$$
$$\frac{1}{f} = \frac{4-1}{200cm}$$
$$\frac{1}{f} = \frac{3}{200cm}$$
$$f = \frac{200}{3}cm$$

We can see that our mirror is a converging mirror since our focal length is positive.

16. Explain why a **NOT-NAND** gate is the same as an **AND** gate.

    Let's look at the following Logic Table to understand how the two are equivalent.

A	B	**AND**	**NAND**	**NOT-NAND**
0	0	0	1	0
0	1	0	1	0
1	0	0	1	0
1	1	1	0	1

    We see that the truth values of the AND gate and the NOT-NAND gate are effectively the same for the same cases, which means the two cases are identical.

17. What does it mean when a P-N junction is reverse biased?

    When we say a diode is reverse biased, we mean that its terminals are attached to a source in such a way that current is not able to pass through it.

18. In a CRO, the distance between the crests of the singal is 10cm. The time base is set at 20ms/cm and the gain control is set at 9V/cm. If the vertical distance between the crests is 18cm, what is the period of the wave?

    The distance between two crests is a distance a wave travels in a single cycle.

$$\text{period} = \text{distance traveled by signal in one cycle} \times \text{ time base}$$
$$\text{T} = 20\text{ms/cm} \times 10cm = 200ms$$

19. What is the magnetic field strength at the center of the solenoid of 500 turns and 90cm long when it is carrying a current of 8A?

$$B = \frac{\mu_0 NI}{l} = \frac{4\pi \times 10^{-7} H/m \times 500 \times 8A}{0.9m}$$
$$B = 1.78 \times 10^{-3}\text{T}$$

20. A coil consists of 2 turns of wire. Each turn is a square of side 1cm and a uniform magnetic field is directed into the plane and it changes from 1.0 to 0.5T in 1 s, what is the magnitude of the induced EMF?

$$\varepsilon = |-\text{N}\frac{\Delta\phi}{\Delta t}|$$

Let's find the flux change(and the area first):

$$A = s^2 = (10^{-2}m)^2 = 10^{-4}m^2$$

$$\varepsilon = |-2 \times \frac{10^{-4}m^2 \times (0.5\text{T} - 1.0\text{T})}{1s}|$$

$$\varepsilon = 1.0 \times 10^{-4}\text{V}$$

21. A transistor is used to amplify current and can also be used as a switch. A transistor has two junctions and what are the three terminals?

    The three terminals of a transistor are the emitter, collector, and the base.

22. The energy stored in the inductor of an RL circuit is given by: $\underline{\frac{1}{2}\text{LI}^2}$

23. Calculate the induced EMF as a result of inductance when the current changes from 10A to 20A in 4 seconds and the inductance is 10H. What will the induced EMF do?

$$\varepsilon = |-\text{L}\frac{\Delta I}{\Delta t}|$$

$$\varepsilon = |-10H \times \frac{20A - 10A}{4s}|$$

$$\varepsilon = 25\text{ V}$$

24. Plot a signal for a CRO for a signal of frequency 200Hz and maximum voltage 4V if the gain control is 2V/cm and time base is 2ms/cm.

    REFER to your ASSIGNMENT for this question or you can alternatively read the text book.

25. Calculate the inductive time constant of a circuit which has an inductor with an inductance of 6mH and a resistor of resistance 500Ω. If the EMF supplied by the battery is 100V, calculate the time needed for the current to drop to 0.1A.

$$\tau_L = \frac{L}{R} = \frac{6 \times 10^{-3}H}{500\Omega} = 1.2 \times 10^{-5}s$$

$$I(t) = \frac{\varepsilon}{R}(1 - e^{\frac{-t}{\tau_L}})$$

$$0.1A = \frac{100V}{500\Omega}(1 - e^{\frac{-t}{\tau_L}})$$

$$0.1A = 0.2A(1 - e^{\frac{-t}{\tau_L}})$$

$$0.5 = (1 - e^{\frac{-t}{\tau_L}})$$

$$0.5 = e^{\frac{-t}{\tau_L}}$$

$$\ln 0.5 = \ln e^{\frac{-t}{\tau_L}}$$

$$\frac{-t}{\tau_L} = -0.693$$

$$t = \tau_L \times 0.693 = 8.316 \times 10^{-6}s$$

26. An object of height 10cm is placed in front of a convex mirror of radius 80 cm 50 cm away from the mirror. Determine the height of the image, how far it is from the mirror, whether it is real or virtual and whether it is upright or inverted.

$$\frac{1}{S_i} = \frac{1}{f} - \frac{1}{S_o}$$
$$\frac{1}{S_i} = \frac{1}{-40cm} - \frac{1}{50cm}$$
$$\frac{1}{S_i} = \frac{-5-4}{200cm}$$
$$\frac{1}{S_i} = \frac{-9}{20cm}$$
$$S_i = \frac{-200cm}{9}$$

We know that:

$$M = \frac{h_i}{h_o} = -\frac{S_i}{S_o}$$
$$h_i = -\frac{S_i}{S_o} \times h_o$$
$$h_i = -\frac{-\frac{200cm}{9}}{50cm} \times 10cm$$
$$h_i = \frac{40}{9}cm$$

Since h_i is positive, we can see that the image is **upright** but since h_i is less than h_o, our image is **diminished** in size. S_i is negative and that implies our image is **virtual**.