FINAL EXAM

Electricity Magnetism & Optics

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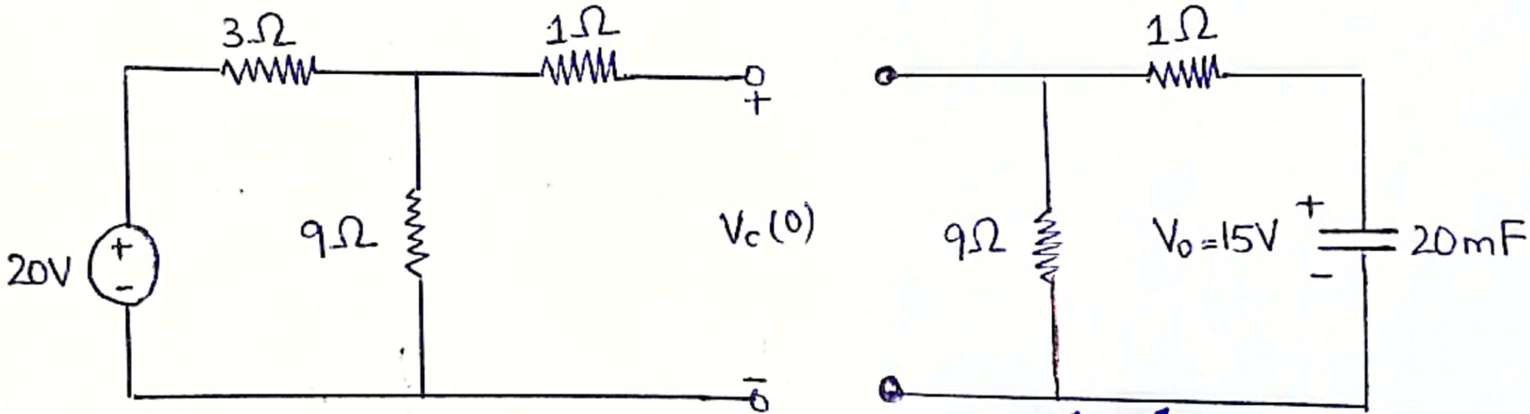
Answer # 1

For $t<0$, the switch is closed; the capacitor is an open circuit to dc, as represented in the fig (a). Using voltage division.

$$V_c(t) = \frac{9}{9+3}(20) = 15\,V, \quad t<0$$

Since the voltage across a capacitor cannot change instantaneously, the voltage across the capacitor at $t=0^-$ is the same at $t=0$, or

$$V_c(0) = V_0 = 15V.$$



(a) $t<0$ (b) $t>0$

For $t>0$, the switch is opened as shown in fig(b). The 1-Ω and 9-Ω resistors in series give.

$$R_{eq} = 1+9 = 10\Omega$$

The time constant is,

$$\tau = R_{eq}C = 10\times 20\times 10^{-3} = 0.2s$$

Thus, the voltage across capacitor for $t \geq 0$ is,

$$V(t) = V_c(0)\,e^{-t/\tau} = 15\,e^{-t/0.2}\,V$$

$$V(t) = 15\,e^{-5t}\,V$$

The initial energy stored in the capacitor is,

$$\boxed{w_c(0) = \frac{1}{2}Cv_c^2(0) = \frac{1}{2}\times 20\times 10^{-3}\times 15^2 = 2.25J}$$

Answer # 2

Which Maxwell equation relate to Magnetism?

Maxwell equation 2 relate to magnetism. This is Gauss's Law for magnetism. It tells us that magnetic field lines (unlike electric field lines) have no begining and no end. In other words, magnetic field lines are continuous.

How Maxwell equation relate to Magnetism?

The second maxwell equation is the analogus one for the magnetic field, which has no source or sinks (no magnetic monopoles, the field lines just flow around in closed curves). Therefore, the net flux out of the enclosed volume is zero.

$$\phi_B = 0 \quad \text{or} \quad \oint_S \bar{B}\cdot\bar{ds} = 0 \quad \text{—— (1)}$$

Apply Guass divergence theorem,

$$\oint_S \bar{B}\cdot\bar{ds} = \oint_V \text{div } B \cdot d_V$$

Put value of $\oint_S \bar{B}\cdot\bar{d}_s$ in eq (1).

$$\oint_V \text{div } B\cdot \cancel{dv} = 0 = \oint_V 0 \cdot \cancel{dv}$$

By comparing,

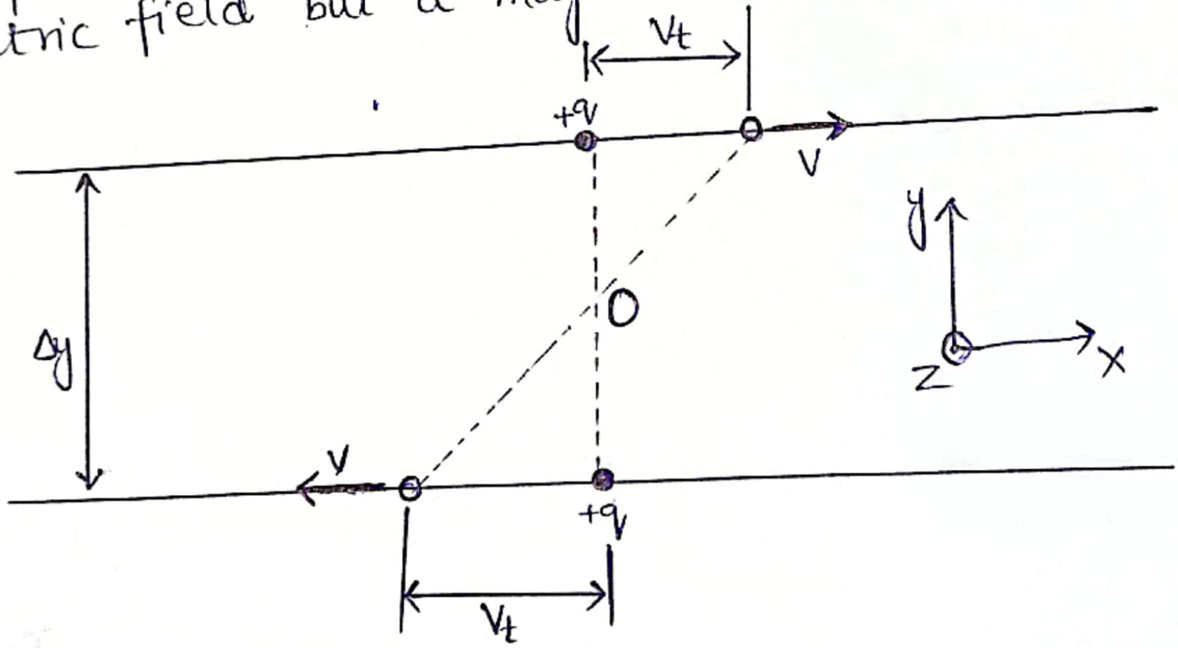
$$\text{div } \bar{B} = 0$$

$$\boxed{\bar{\nabla}\cdot\bar{B} = 0}$$

Answer #3

Maxwell third equation is derived from Faraday's law of electromagnetic induction. It states that whenever there are n-turns of conducting coil in a closed path which is placed in a time-varying magnetic field, an alternating electromotive force gets induced in each and every coil. This is given by Lenz's Law which states that an induced electromotive force always oppose the time-varying magnetic flux.

Assume two similar point charges located at a distance Δy away from each other are set in motion with the same velocity v in opposite directions. The lab observer located at point O in the mid-way between the charges detects no electric field but a magnetic one complying with,



$$B_z = 2\frac{v}{c^2}E_y,$$

where E_y is the transverse component of the electric field of each moving charge at point O, which is equal to:

$$E_y = \frac{q\gamma(\Delta y/2)}{4\pi\varepsilon_0\left[\gamma^2 v^2 t^2 + (\Delta y/2)^2\right]^{3/2}}$$

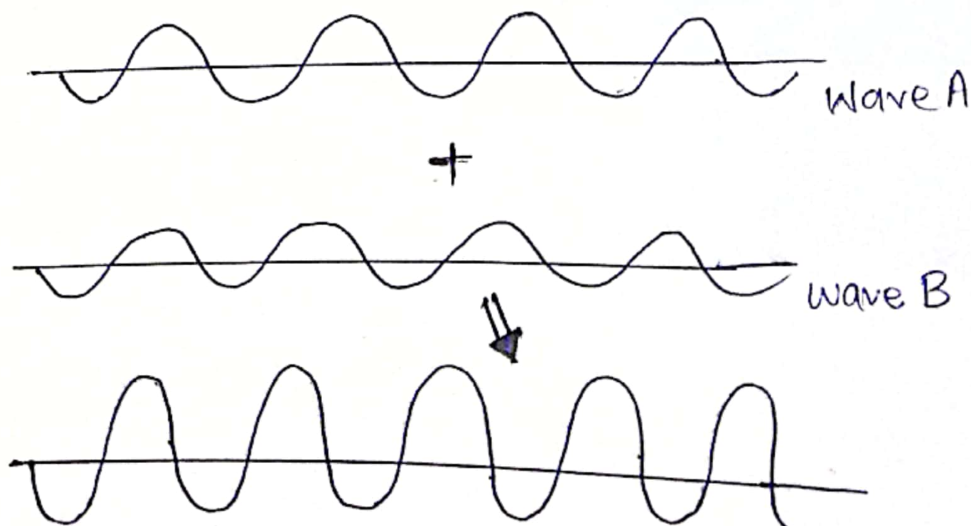
Answer #4

Electromagnetic waves refers to the waves of electromagnetic field, propagating through space, carrying electromagnetic radiant energy. Both light waves and radio waves are examples of electromagnetic waves, meaning that they fall on the same electromagnetic spectrum as infrared waves, ultraviolet waves and microwaves. Because these are all waves, they all have a wavelength that determines the distance over which their amplitude changes. Radio waves can have wavelengths as wide as your arms, while visible light waves have wavelength as small as thousandth of the width of a human hair.

Example:

For example, constructive interference and destructive interference.

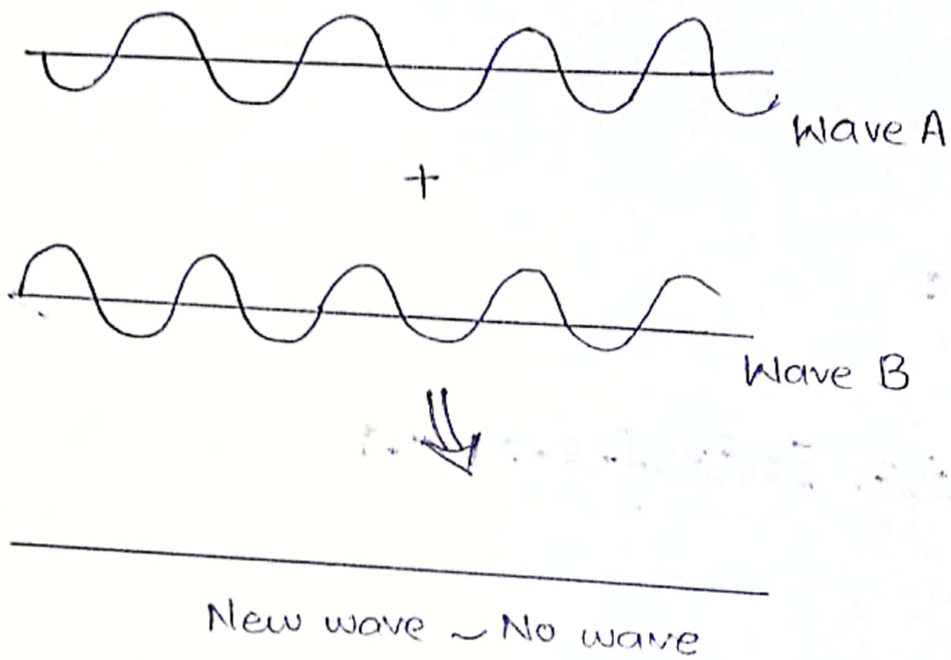
Constructive Interference: Constructive interference occurs when the maxima of two waves add together (the two waves are in phase), so that the amplitude of resulting wave is equal to the sum of individual amplitudes. The bright regions occur whenever an integer number of waves constructively interfere. **e.g.** two speakers playing same music while facing each other. At this time, music will appear louder and powerful as compared to music played by single speaker.



New wave has same wavelength as wave A and wave B, but has larger amplitude.

Destructive Interference: Occurs when the maxima of two waves are 180 degree out of phase: a positive displacement of one wave is cancelled exaclly by a negative displacement of the other wave. The amplitude of the resulting wave is zero. The dark regions occur whenever the waves destructively interfere.

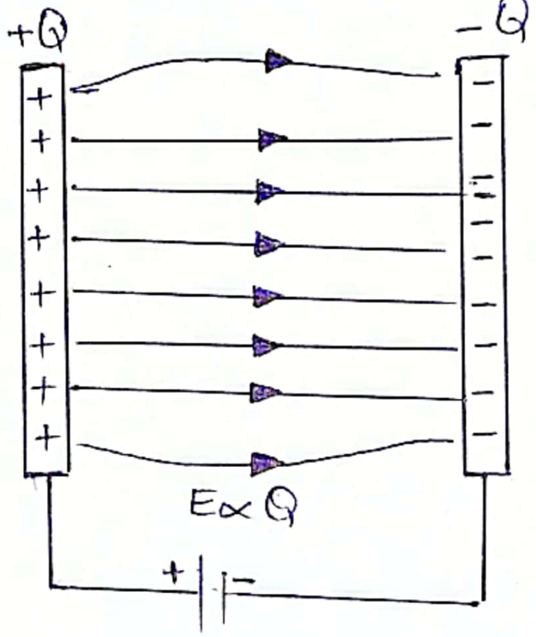
e.g. headphones noice cancellation.



Answer # 5

Capacitance of Capacitor in presence of Dielectric

A capacitor is a device used to store electric charge. When a dielectric slab is placed between a charged capacitor, the atoms present in dielectric align themselves to form a dipole. The dielectric doesn't allow the charge to pass through it. But some of the charge will be stored on the surface of dielectric. (Total charge on capacitor will remain constant).



The field is proportion to the charge:

$$E \propto Q$$

We know that the voltage across the parallel plates is

$$V = Ed$$

Thus $V \propto E$. It follows, then, that $V \propto Q$, and conversely

$$Q \propto V$$

Different capacitors will store different amounts of charge for same applied voltage, depending on their physical characteristics.

$$Q = CV$$

Here C is the capacitance. It is defined as the amount of charge stored per volt, or.

$$\boxed{C = \frac{Q}{V}}$$

As electric field b/w the plates is uniform. When dielectric is placed b/w the plates, electric field is given as,

$$E = \frac{q}{A\varepsilon_0}$$

As - $V = Ed$, $E = \frac{V}{d}$

So,

$$\frac{V}{d} = \frac{q}{A\varepsilon_0}$$

$$\frac{q}{V} = \frac{A\varepsilon_0}{d}$$

We know, that, $C = \frac{q}{V}$

$$\boxed{C = \frac{A\varepsilon_0}{d}}$$

If the medium is dielectric then,

$$C = \frac{A\varepsilon_0 k_e}{d}$$

Equivalent Capacitance:

⇒ Capacitors in Series:

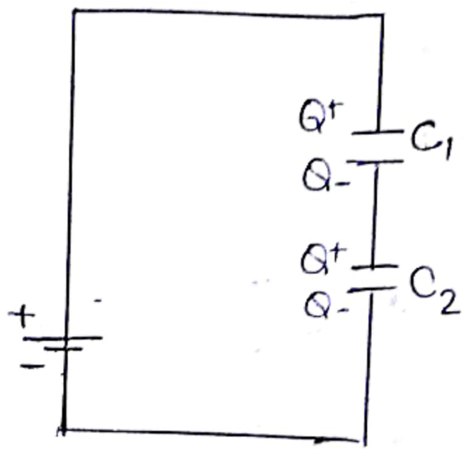
capacitors in series provide single path for current.

$$C = \frac{Q}{V}$$

$$C \propto \frac{1}{V}$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \text{------} + \frac{1}{C_n}$$

$$C_{eq} = \frac{C}{n}$$



⇒ Capacitors in Parallel:

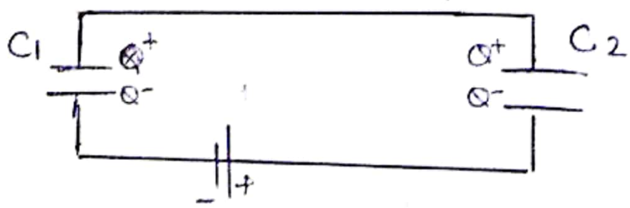
Capacitors in parallel provide more than one path for current.

$$Q = CV$$

$$Q \propto C$$

$$C_{eq} = C_1 + C_2 + \text{-----} + C_n$$

$$C_{eq} = nC$$



Answer # 6

Electric Flux:

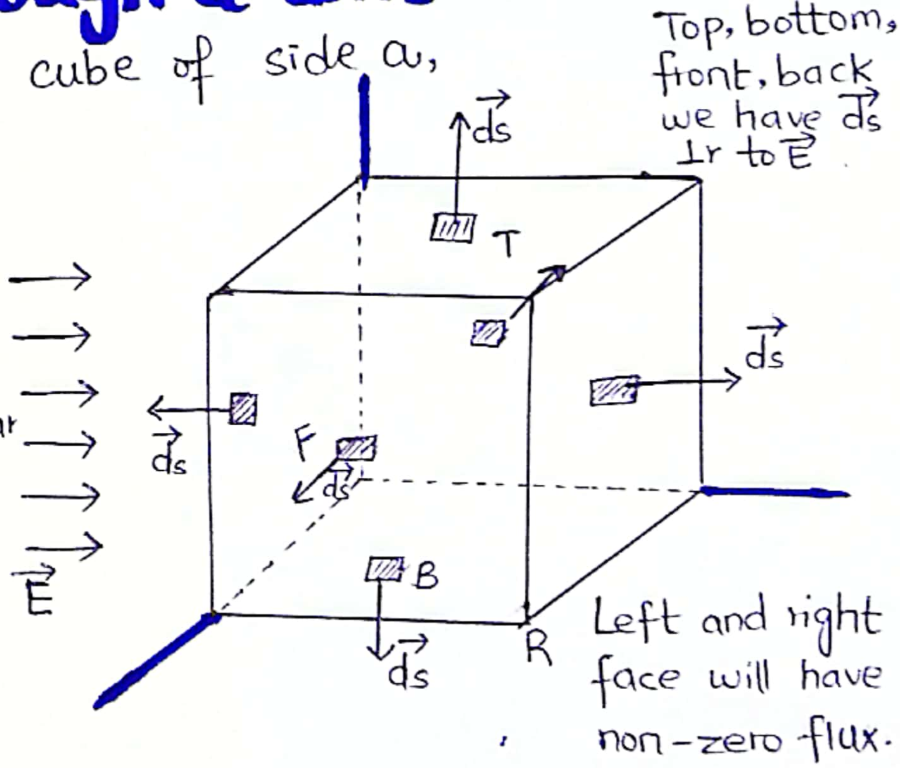
The number of electric field lines passing through a certain element of area is called electric flux through that area. OR

Scalar product of electric field intensity $\vec{E}$ and area vector $\vec{A}$ is called electric flux.

$$\phi = \vec{E} \cdot \vec{A} = EA\cos\theta.$$

Electric flux through a unit Cube:

Electric flux through a cube of side a,



If $\vec{ds} \perp \vec{E}$, then

$\vec{E} \cdot \vec{ds} = Ed\cos\theta = 0$

We need to consider faces where $\vec{ds}$ is not prependicular to $\vec{E}$.

Left:

$$\oint \vec{E} \cdot \vec{ds} = \int E \cdot ds \cos\theta$$

$\therefore \quad \theta = 180^\circ$

$\cos\theta = -1$

$$= \int -E \cdot ds = E\int ds$$

As $\int ds = a^2$

So,

$$= -Ea^2$$

Right:

$$\oint \vec{E} \cdot \vec{ds} = \int Ed\cos\theta$$

$\therefore \theta = 0$

$\cos 0 = 1$

$$= E\int ds = Ea^2$$

Net Flux: $\underset{L}{-Ea^2} + \underset{R}{Ea^2} + \underset{T}{0} + \underset{B}{0} + \underset{F}{0} + \underset{B}{0} = 0$