Solution

QP code . 35461

Physics F.Y. B.Sc. sem II paper II 20.4.2018

Q-1 A Select the correct options 12 marks (2 marks each)

(i) (c) purely resistive

(ii) (a) $\frac{E_0}{\sqrt{2}}$

(iii) (d) equal to the load

(iv) (c) voltage regulator

(v) (c) A

(vi) (a) $-30\ V/m$.

B

(i) Superposition Theorem (1 mark)

In a network with two or more sources, the current or voltage for any component is the algebraic sum of the effects produced by each source acting separately. (Network should consists of bilateral and linear components only)

(ii) Wien's Bridge determines frequency of the source (1 mark)

(iii) Electric field at any pt. is the measure of force $\vec{F}$ on a test charge q_0. (1 mark)

$$\vec{E}(r) = \lim_{q_0 \to 0} \frac{\vec{F}}{q_0}$$

The unit of $\vec{E}$ is N/C or V/m.

(c) Fill in the blanks — 5 marks (1 mark each)

(i) equal
(ii) zero
(iii) conservative field
(iv) infinite
(v) interchanged

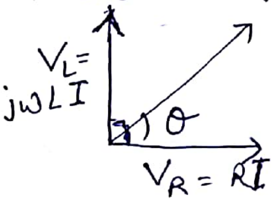
Q-2 A

(i) Circuit Diagram of series LR circuit — 1 mark

Derivation for

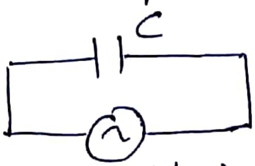
$i = I_0 \sin(\omega t - \theta)$ using complex numbers — 5 marks.

Phasor. $V = ZI$ — 1 mark



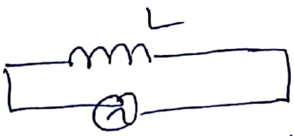
$|I|$ = rms current flowing thr' the circuit $= \frac{I_0}{\sqrt{2}}$, $\frac{V}{Z} = I = |I| e^{-j\theta}$

(ii) circuit diagram — 1 mark



$i(t) = \omega C V_0 \sin(\omega t + \pi/2)$ — 2 marks

phasor — 1 mark



$i(t) = i_0 \sin \omega t$ — 1 mark

$V(t) = \omega L I_0 \sin(\omega t + \pi/2)$ — 2 marks

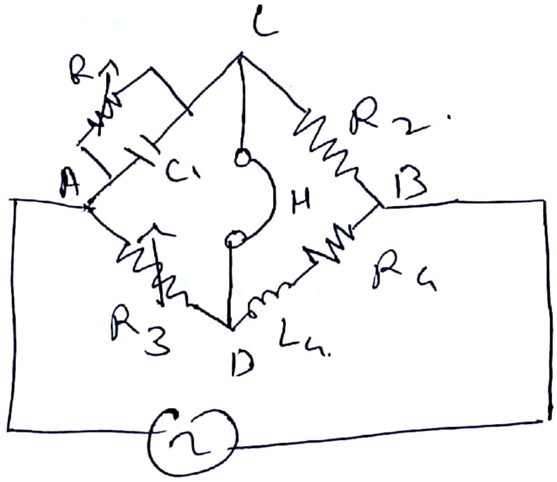
Voltage across inductor leads the current — 1 mark.

phasor

B

(i) Circuit Diagram of Maxwell's L/C bridge — 2 marks

~~Derivation for~~



6 marks

Derivation for

$$R_4 = \frac{R_2 R_3}{R_1}$$

$$L_4 = R_2 R_3 C_1$$

(ii) Circuit Diagram — 1 mark.

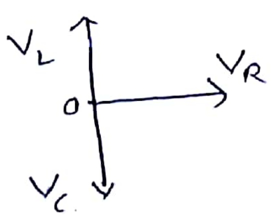
Derivation for

$$Z = |Z| e^{j\theta} = R + j\left(\omega L - \frac{1}{\omega C}\right)$$

where $|Z| = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$

$$\tan\theta = \frac{\left(\omega L - \frac{1}{\omega C}\right)}{R}$$ — 5 marks

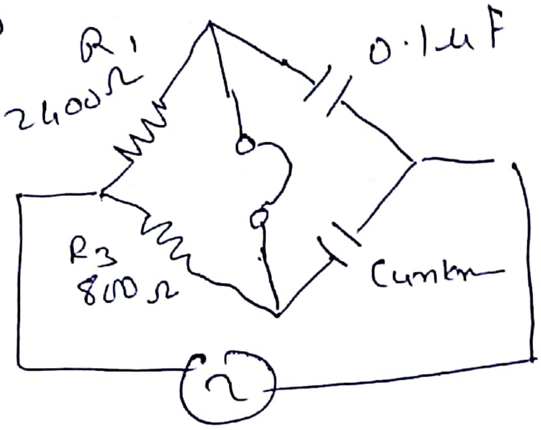
Phasor for Resonance condition $\omega L = \frac{1}{\omega C}$



— 2 marks.

(C)

(i)



4 marks

~~Cunknown~~

$$Z_1 = Z_3$$

$$Z_2 = Z_4$$

$$Z_1 Z_4 = Z_2 Z_3$$

$$R_1 \left(-\frac{j}{\omega C_x}\right) = \left(-\frac{j}{\omega C_2}\right) \times R_4$$

$$\therefore \; C_x = \frac{R_1}{R_4} C_2$$

$$= \frac{2400}{800} \cdot 0.1 \, \mu F$$

$$C_x = 0.3 \, \mu F$$

ii) $$\omega = \sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

– 4 marks

$$f = \frac{1}{2\pi} \sqrt{\frac{1}{LC} - \frac{R_2}{L^2}}$$

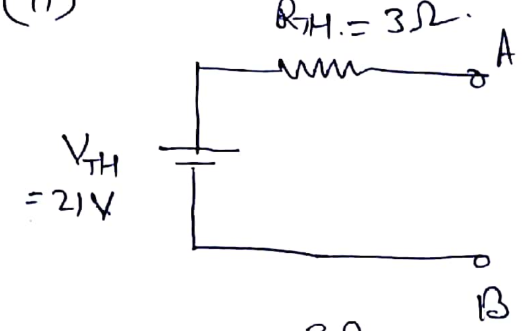
$$f = 112533 \text{ Hz}$$

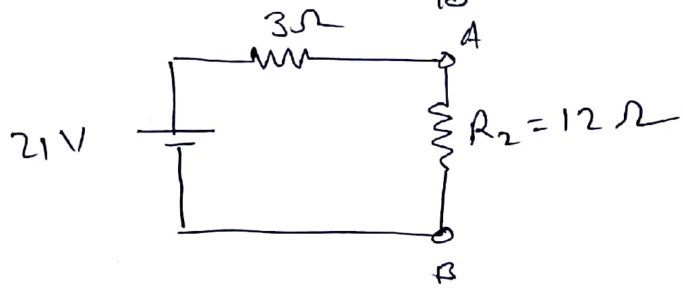
Q-3 A

(i) Statement of maximum power transfer theorem — 2 marks

Proof of the theorem — 6 marks

(ii)





$V_{R_2} = 16.8\ V$

$I_{R_2} = 1.4\ A.$

B

(i) Circuit diagram of Bridge rectifier. — 2 marks.

Working of the bridge rectifier — 4 marks

input & output waveforms — 2 marks.

(ii) Answer why NOR & NAND are universal gates. — 2 marks.

Using NAND gates construct other gates — 3 marks

Using NOR gates construct other gates — 3 marks

(c) (i) Without Zener voltage across 1 kΩ resistor will be

$$V_R = 1\,k\Omega \times \frac{18\,V}{1.27 \times 10^{3}}$$

$$= 14.2 \text{ volts}$$

This is greater than Zener breakdown Voltage of 10 volts ∴ Zener will go in the breakdown state. – 2 marks

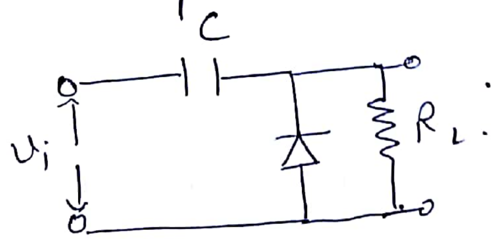
Maximum current that can pass thro' Zener

$$P = IV$$

$$250\,mW = 10 \text{ volts} \times I$$

$$\therefore \underline{I = 25\,mA}$$ 2 marks

(ii) Circuit Diagram of +ve clamper – 2 marks



Voltage levels at the output – 2 marks

0V – 16 V

Q- 4 A

(i) Derivation with figure of - 6 marks

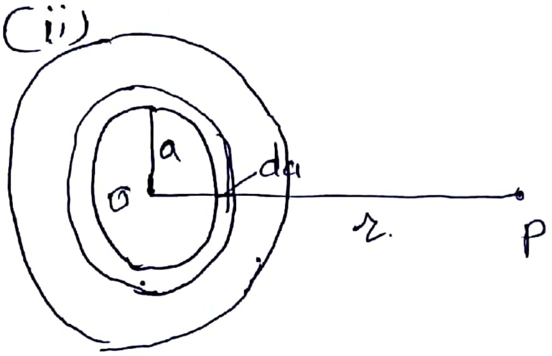
Potential energy of pt-charge distribution,

$$W = \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N}\frac{q_i q_j}{4\pi\epsilon_0 r_{ij}}, \quad i \neq j$$

$$W = \frac{1}{2}\sum_{i=1}^{N} q_i V(r_i) \quad \text{where}$$

$$V(r_i) = \sum_{j=1}^{N}\frac{q_j}{4\pi\epsilon_0 r_{ij}}$$

(ii) 6 marks.



$$\sigma = \frac{q}{\pi R^2} \quad \because R \text{ radius of the disc}$$

$$V = \frac{2q}{(4\pi\epsilon_0)R^2}\left[\sqrt{R^2+r^2} - r\right]$$

B

(i) magnetic field produced by solenoid.

Figure - 3 marks

Derivation 5 marks

$$B = \frac{\mu_0 N I}{2L}(\cos\theta_1 + \cos\theta_2)$$

For very long solenoid

$$B = \frac{\mu_0}{2}\left(\frac{N}{L}\right) I$$

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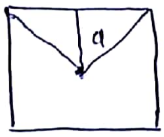
(ii) Figure – 1 marks

Derivation ~~6~~ 5 marks.

$$B = \frac{\mu_0 I}{4\pi a}(\sin\theta_1 + \sin\theta_2)$$

B due current 'I' carrying square at center of the square,



$\cancel{B = \mu_0 I}$

$$B = \frac{4\mu_0 I}{4\pi a}(\sin\theta_1 + \sin\theta_2)$$

$$= \frac{\cancel{4}\mu_0 I}{\cancel{4}\pi a}(2 \times \sin 45^\circ)$$

$$\boxed{B = 1.41\frac{\mu_0 I}{\pi a}}$$ – 2 marks.

(c)(i)

$B = \mu_0 n I$

$n = \frac{2000}{0.5}$, $I = ?$

$\mu_0 = 4\pi \times 10^{-7}\ N/A^2$

$\therefore B = 0.01T$

$I = 1.99\ A \simeq 2\ A.$

(ii)

$$V_B - V_A = \frac{500\ mJ}{Q}$$

$$= \frac{500 \times 10^{-3}\ J}{0.1\ C}$$

$$= 5000 \times 10^{-3}\ \text{volts}$$

$$= 5\ \text{volt}.$$

Q-5

(i) Definition of Q factor - 2 marks

Q factor is voltage magnification.
& is defined as a ratio of p.d. across the inductance or capacitance to the applied emf at resonance.

$\cancel{Q = \frac{\omega_0 L}{R}}$

Derivation of - 2 marks

$$Q = \frac{\omega_0 L}{R}$$

Significance 1 mark

(ii) Statement of De Morgan's 2 marks
any theorem

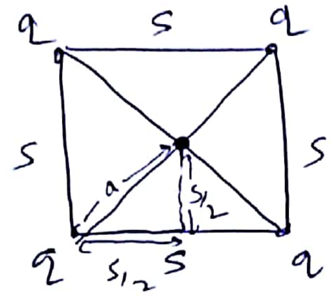
Circuit equivalent & 3 marks
Truth table

iii) Circuit diagram of the filter circuit - 1 mark

Action of capacitor with the waveforms - 4 marks

(iv) Total work done - 4 marks

$$W = \frac{1}{4\pi\epsilon_0}\frac{4\sqrt{2}\,qQ}{s}$$



Potential at the center due to 4 charges 'q' $V = \frac{1}{4\pi\epsilon_0}\frac{4q}{a}$

$$a^2 = \frac{s^2}{4} + \frac{s^2}{4}.$$

$$a^2 = \frac{2s^2}{4}$$

$$a = \sqrt{2}\frac{s}{2} = \frac{s}{\sqrt{2}}$$

$$\therefore V = \frac{1}{4\pi\epsilon_0}\frac{4q}{s/\sqrt{2}}$$

$$\therefore W = \frac{1}{4\pi\epsilon_0}\frac{4qQ}{s/\sqrt{2}}$$

$$= \frac{\sqrt{2}}{4\pi\epsilon_0}\frac{4qQ}{s}$$

v) Magnetic field at the center of current carrying square loop.

$$B = \frac{4 \times \mu_0 I}{4\pi a} (\sin\theta_1 + \sin\theta_2)$$

$$= \frac{4 \times \mu_0 I}{4\pi a}(2 \sin 45^\circ)$$

$$= \frac{4 \times \mu_0 I}{4\pi a} \quad 2 \times 0.707$$

$$= \frac{1.41 \mu_0 I}{\pi a}$$

(vi) $$\overline{V^2} = \frac{\int_0^T V^2 dt}{\int_0^T dt}$$

$$\overline{V^2} = \frac{1}{T} \int_0^T V_0^2 \sin^2 \omega t \, dt$$

$$= \frac{V_0^2}{T} \int_0^T \left(\frac{1 - \cos 2\omega t}{2}\right) dt$$

$$= \frac{V_0^2}{2T} \left[T - \frac{\sin 2\omega t}{\omega}\right]_0^T$$

$$\overline{V_0^2} = \frac{V_0^2}{2\cancel{T}} \cancel{T}$$

$$V_{rms} = \sqrt{\overline{V^2}} = \frac{V_0}{\sqrt{2}}$$ - 2 marks

V_{av} ~~for~~ for full cycle $= 0$ - 1 mark

V_{av} for half cycle $= \frac{\int_0^{T/2} V \, dt}{\int_0^{T/2} dt}$ - 2 mark

$$= \frac{2 V_0}{\pi}$$