Questions from GATE 2025 -EC /EE Papers - EMFT

1. Basics of Electromagnetics

Q1. Let $\boldsymbol{a_R}$ be the unit radial vector in the spherical co-ordinate system.

For which of the following value(s) of *n,* the divergence of the radial vector field

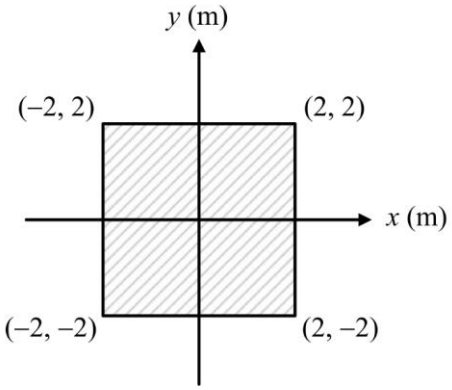
$$\boldsymbol{f(R)}=\boldsymbol{a_R}\frac{1}{R^n}$$ is independent of *R*?

A) -2 B) -1 C) 1 D) 2

Answer (B and D)

Q2. A square metal sheet of 4 m x 4 m is placed on the x-y plane as shown in the figure below.

If the surface charge density (in μC/m^2) on the sheet is ρ_s (x, y) = 4|y|, then the total charge (in μC, rounded off to the nearest integer) on the sheet is……. **(GATE EC 2025) (2 Marks)**



A) 16 B) 85 C) 64 D)26

Answer (C)

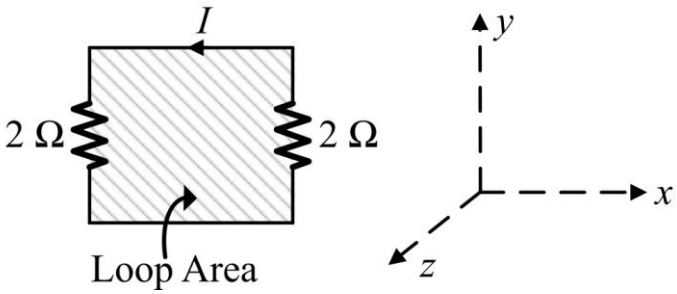
Q3. An electric field of 0.01 V/m is applied along the length of a copper wire of circular cross-section with diameter 1 mm. Copper has a conductivity of 5.8 x 10^7 S/m. The current (in Amperes, rounded off to two decimal places) flowing through the wire is…….. **(GATE EC 2025) (2 Marks)**

A) 0.46 B) 1.82 C) 0.58 D) 1.12

Answer (A)

Q4. Two resistors are connected in a circuit loop of area 5 m^2, as shown in the figure below. The circuit loop is placed on the x-y plane. When a time-varying magnetic flux, with flux-density B (t) = 0.5t (in Tesla), is applied along the positive z-axis, the magnitude of current I (in Amperes, rounded off to two decimal places) in the loop is …….

(GATE EC 2025) (2 Marks)



Answer (0.625)

Q5. Which one of the following figures represents the radial electric field distribution ER caused by a spherical cloud of electrons with a volume charge density,

$\rho=-3\rho_0$ for $0\leq R\leq a$ (both ρ_0, a are positive and R is the radial distance)

$\rho=0$ for $R>a$

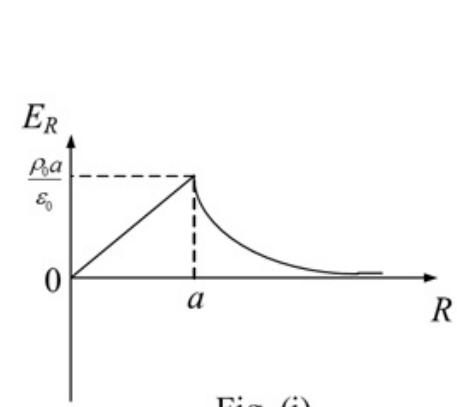


Fig. (i)

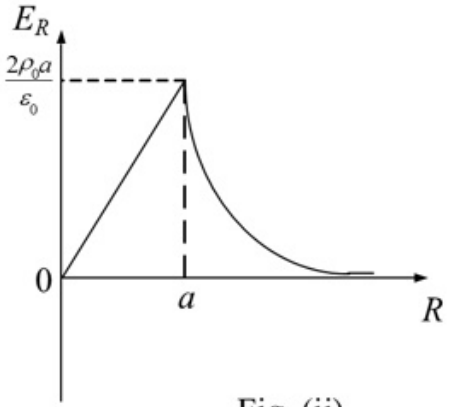


Fig. (ii)

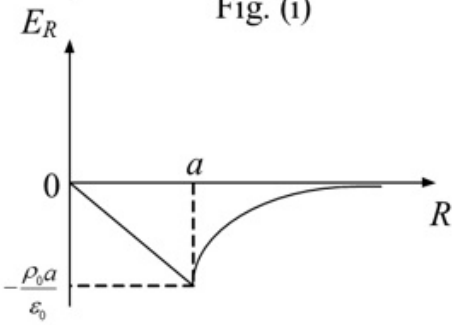


Fig. (iii)

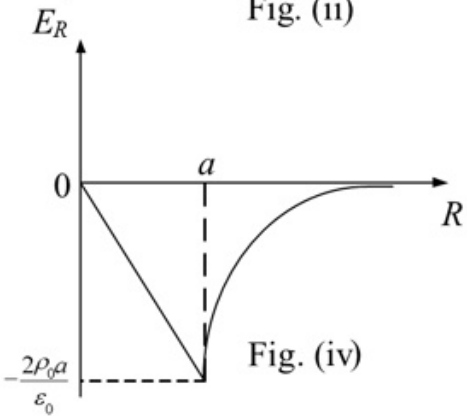


Fig. (iv)

A) Figure 1 B) Figure 2 C) Figure 3 D) Figure 4

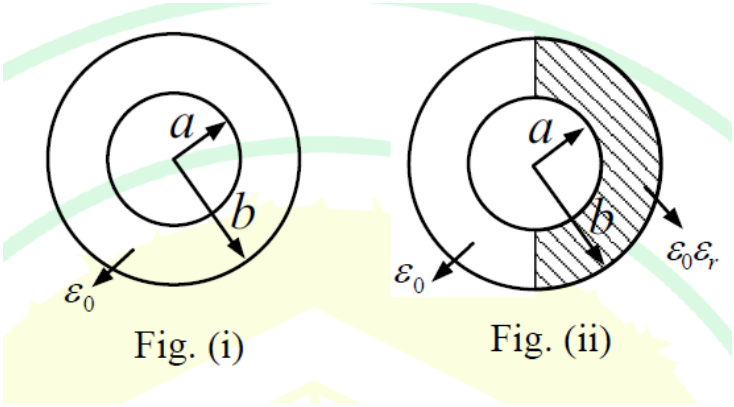
(GATE EE 2025) (1 Mark)

Answer (C)

Q6. An air filled cylindrical capacitor (capacitance C_0) of length L, with a and b as its inner and outer radii, respectively, consists of two coaxial conducting surfaces.

Its cross-sectional view is shown in Fig. (i). In order to increase the capacitance, a dielectric material of relative permittivity εr is inserted inside 50% of the annular region as shown in Fig. (ii).

The value of ε_r for which the capacitance of the capacitor in Fig. (ii), becomes $5C_0$ is



A) 4 B) 5 C) 9 D)10

(GATE EE 2025) (2 Marks)

Answer (C)

Q7. A 50 Ω lossless transmission line is terminated with a load Z_L of (50 - j75) Ω, If the average incident power on the line is 10 mW, then the average power delivered to the load (in mW, rounded off to one decimal place) is

(GATE EC 2025) (2 Marks)

Answer (6.4 W)

Solutions – Questions GATE 2025 – EC / EE - EMFT

Q1. Divergence of a vector = $\nabla.A = \frac{1}{R^2}\frac{d}{dR}(R^2\ \frac{1}{R^n}) = \frac{1}{R^2}\frac{d}{dR}(R^{2-n})$

When n = 2, Divergence is zero and independent of R
When n = -1, Divergence is 3 and independent of R

Q2. Total Charge Q = $\iint 4|y|\ dx\ dy$ with limits -2 to 2 for x and y

= $\iint 4\ 2y\ dx\ dy$ with limits -2 to 2 for x and 0 to 2 for y = 64 μC

Q3. $J = \sigma E$,

$I = \sigma\ A\ E = 5.8\ X\ 10^7\ X\ \pi\ (\frac{1}{2})^2\ X\ 0.01 = 0.46$

Q4. $V = -\frac{d\ (B\ A)}{dt} = -\ 0.5\ X\ 5 = 0.25\ V$

$I = \frac{V}{R} = \frac{0.25}{4} = 0.625\ A$

Q5. Electric field can be calculated using Gauss Law,

$D.\ 4\pi\ R^2 = -3\rho_0\ \frac{4}{3}\ \pi\ R^3$

$D = -\rho_0\ R \quad R < a$

$E = D/\varepsilon$

It is a linear increase up to the surface of the charge and then decreases as we move out of the sphere.

Q6. Capacitance of a coaxial cable = $\frac{2\pi\varepsilon\ L}{Ln\ (\frac{b}{a})} = Co$

Capacitance of the coaxial cable with 2 dielectrics in parallel

(Dielectrics filling half space from 0 to π instead of 0 to 2π)

$$= \frac{\pi\varepsilon\ L}{Ln\ (\frac{b}{a})} + \frac{\pi\varepsilon\varepsilon_r\ L}{Ln\ (\frac{b}{a})} = 5Co$$

This requires $\varepsilon_r = 9$

Q7. Voltage reflection coefficient $\Gamma = \frac{50-j75-50}{50-j75+50} = \frac{j75}{100-j75}$

$$|\Gamma| = \left|\frac{j75}{100-j75}\right| = 0.6$$

Power Reflection coefficient = -0.36

Power Transmission coefficient = 0.64,

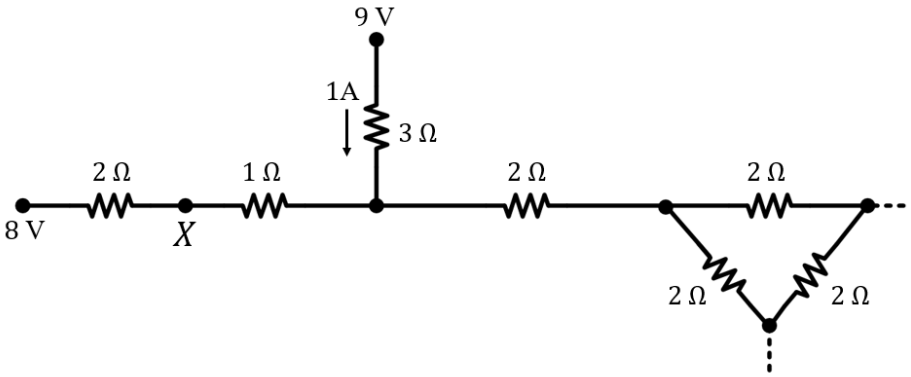
Power delivered to the load = 10 x 0.64 = 6.4 Watts

Questions from GATE 2025 -EC /EE - NETWORKS

1.Basics of Network Analysis

Q1. Consider a part of an electrical network as shown below.

Some node voltages, and the current flowing through the 3Ω resistor are as indicated. The voltage (in Volts) at node X is _____. **(GATE EC 2025)**

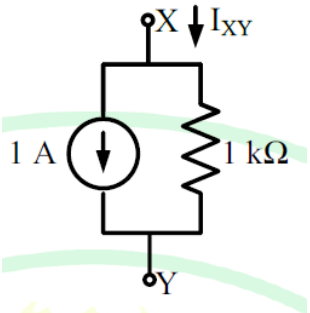


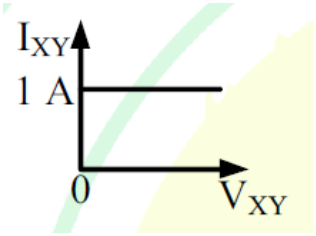
A) 20/3 B) 32/3 C) 22/3 D)2/3

Answer (A)

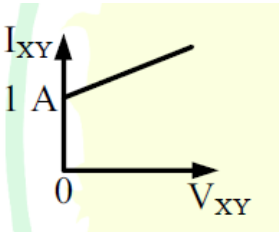
Q2. The I-V characteristics of the element between the nodes X and Y is best depicted by,

(GATE EE 2025)

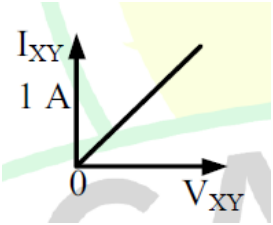




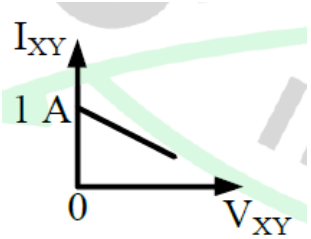
A.



B.



C.



D.

Answer (B)

Q3. A nullator is defined as a circuit element where the voltage across the device and the current through the device are both zero.

A series combination of a nullator and a resistor of value, R, will behave as a

(GATE EE 2025)

A) Value of resistor R
B) Open circuit
B) nullator
D) Short circuit.

Answer (B)

2.Sinusoidal Steady State Analysis

Q4. In the circuit below,
$M1$ is an ideal AC voltmeter and $M2$ is an ideal AC ammeter.

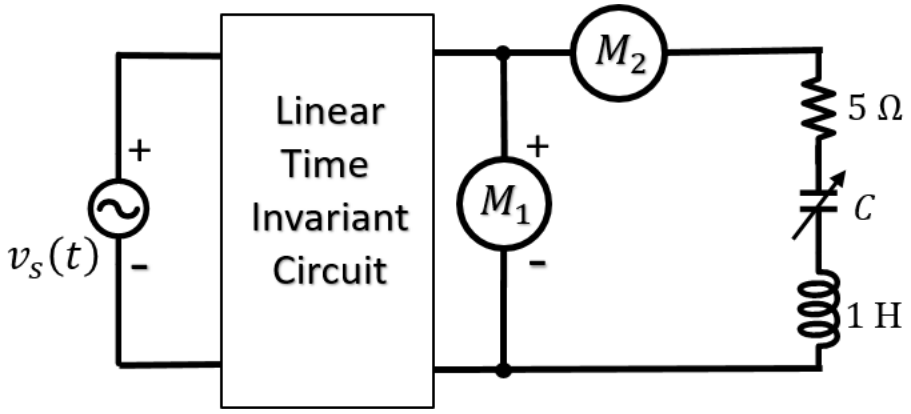
The source voltage (in Volts) is $vs(t)=100\cos(200t)$.

What should be the value of the variable capacitor C such that the RMS readings on $M1$ and $M2$ are 25 V and 5 A, respectively

(GATE EC 2025)

A) 25 μF B) 4 μF C) 0.25μF D) Data insufficient

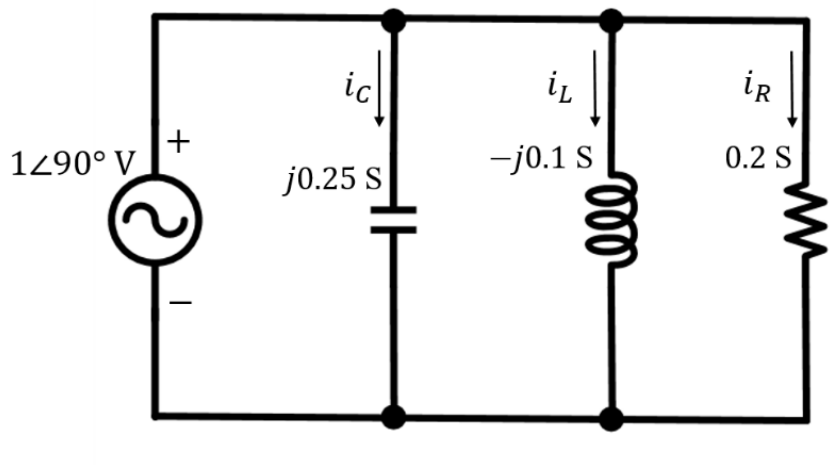
Answer (A)



Q5. Let i_C, i_L, and i_R be the currents flowing through the capacitor, inductor, and resistor, respectively, in the circuit given below.

The AC admittances are given in Siemens (S).
Which one of the following is TRUE? **(GATE EC 2025)**

Answer (A)



A) i_C=0.25∠180° A, i_L=0.1∠0° A,i_R=0.2∠90° A

B) i_C=4∠180° A, i_L=10∠0° A,i_R=5∠90° A

C) i_C=0.25∠270° A, i_L=0.1∠90° A,i_R=0.2∠90° A

D) i_C=4∠90° A, i_L=10∠270° A,i_R=5∠0° A

Q6. Consider two coupled circuits, having self-inductances L_1 and L_2, that carry non-zero currents I_1 and I_2, respectively.
The mutual inductance between the circuits is M with unity coupling coefficient.
The stored magnetic energy of the coupled circuits is minimum at which of the following value(s) of $\frac{I_1}{I_2}$?

A) $\frac{-M}{L_1}$ B) $\frac{-M}{L_2}$ C) $\frac{-L_1}{M}$ D) $\frac{-L_2}{M}$

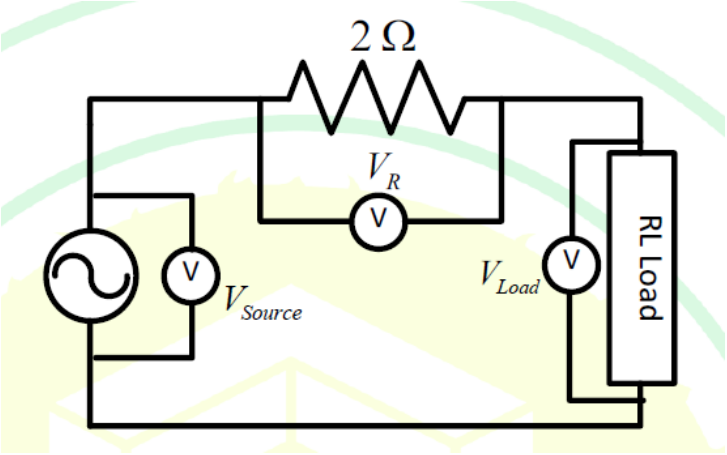
Answer (A, D) **(GATE EE 2025)**

Q7. In an experiment to measure the active power drawn by a single-phase R_L Load connected to an AC source through a 2 Ω resistor, three voltmeters are connected as shown in the figure below.

The voltmeter readings are as follows: V_{Source} = 200 V, V_R = 9 V, V_{Load} = 199 V.

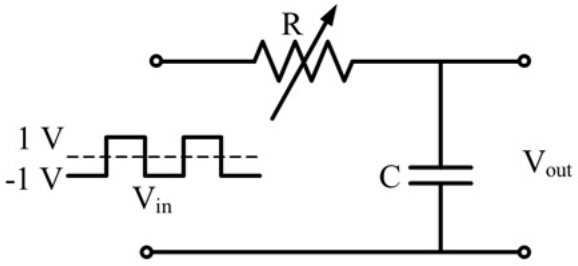
Assuming perfect resistors and ideal voltmeters, the Load-active power measured in this experiment, in W, is _____(round off to one decimal place).

Answer (77- 80) **(GATE EE 2025)**

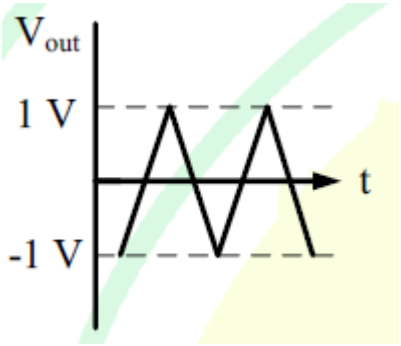


3.Transient Analysis

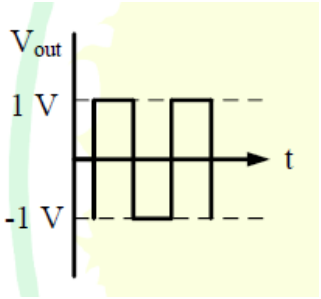
Q8. In the circuit shown, if the values of R and C are very large, the form of the output voltage for a very high frequency square wave input , is best represented by **(GATE EE 2025)**



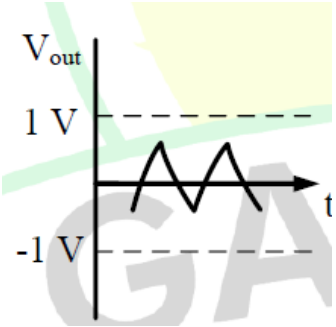
A)



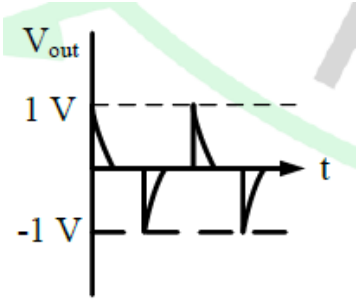
B)



C)



D)

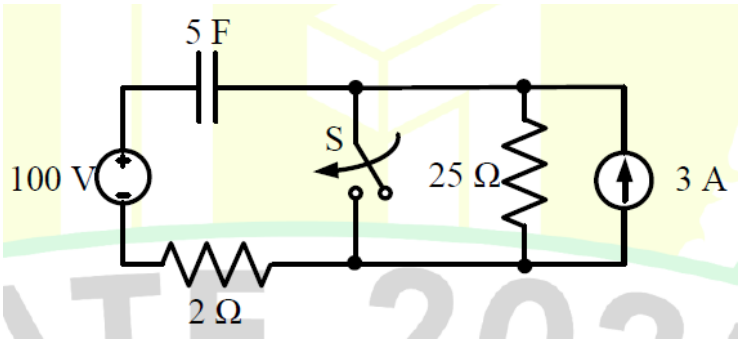


Answer (C)

Q9. The switch (S) closes at t=0 sec. The time, in sec, the capacitor takes to charge to 50 V is _____ (round off to one decimal place).

(GATE EE 2025)

Answer (4.0 – 4.2)



4.Two Port Networks

Q30. The Z-parameter matrix of a two port network relates the port voltages and port currents as follows,

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = Z \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

The Z matrix (with each entry in Ohms) of the network shown below is

(GATE EC 2025) (2 Marks)

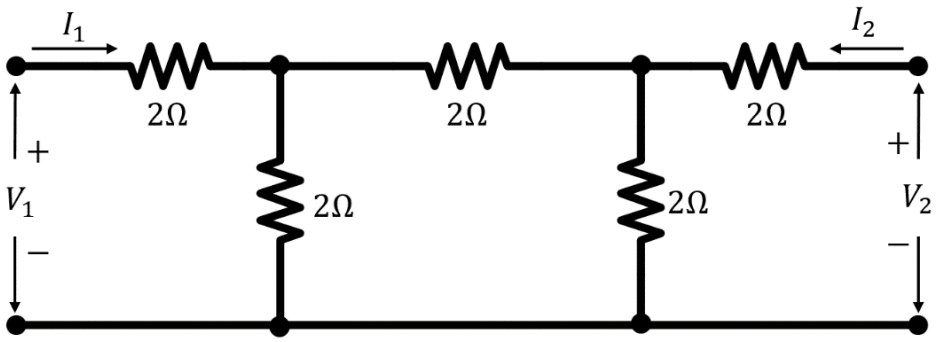
A) $\begin{bmatrix} 10/3 & 2/3 \\ 2/3 & 10/3 \end{bmatrix}$

B) $\begin{bmatrix} 2/3 & 10/3 \\ 10/3 & 2/3 \end{bmatrix}$

C) $\begin{bmatrix} 10 & 2 \\ 2 & 10 \end{bmatrix}$

D) $\begin{bmatrix} 10/3 & 1/3 \\ 1/3 & 10/3 \end{bmatrix}$

Answer (A)



Solutions Questions GATE 2025 – EC/ EE -NETWORKS

Q1. The voltage after 3Ω is 6V due to 1A current and 9v at other end.

The current in the 2 and 1 Ω branch is (8-6)/3 = 0.66 A

The voltage at X = 8 – 2 x 0.66 = 20/3 V

Q2. The current increases linearly from 1A due to the current source.

Q3. The voltage and current both being zero, result is nullator

Q4. The circuit 25V and 5 A = 5Ω, the circuit is in resonance

$\omega = 200$, $X_L = 1/X_C$, $\omega = 1/\sqrt{LC}$, $C = 0.25\ \mu F$

Q5. $V = I\,R = I/G = \frac{Ic}{j0.25} = \frac{I_L}{-j0.1} = \frac{I_R}{0.2}$,

Check for options, Option A satisfies the equation.

Q6. The total energy $E = \frac{1}{2} L_1 I_1^2 + \frac{1}{2} L_2 I_2^2 + M I_1 I_2$

For minimum $dE/dI_1 = 0$ and $dE/dI_2 = 0$

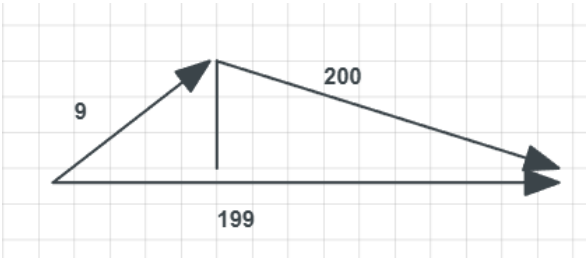
$dE/dI_1 = L_1 I_1 + + M I_2 = 0$,

Similarly, $dE / dI_2 = 0$, gives the answer.

Q7. The total power = V I cos(θ),

V = 199, I = 4.5, cosθ need to be known

where θ is the phase angle of the circuit,



$200^2 = (9 + 199\cos(\theta)^2 + (199\ \sin(\theta))^2$

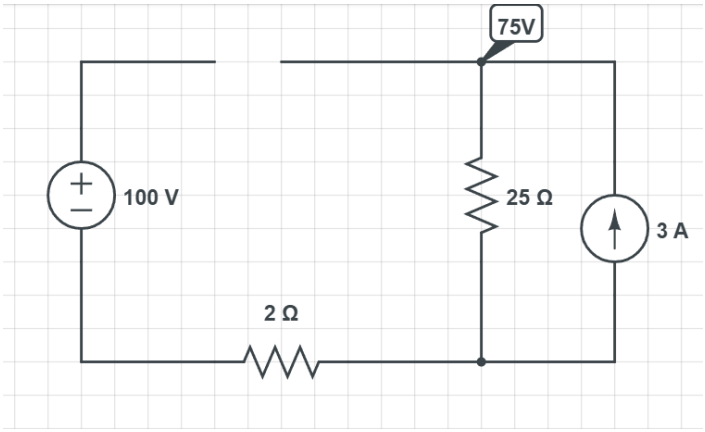
This gives, $\cos\theta = 0.0887$,

Power = 199 x 4.5 x 0.0887 = 80 Watts

Q8. The circuit acts as an integrator for a large time constant,

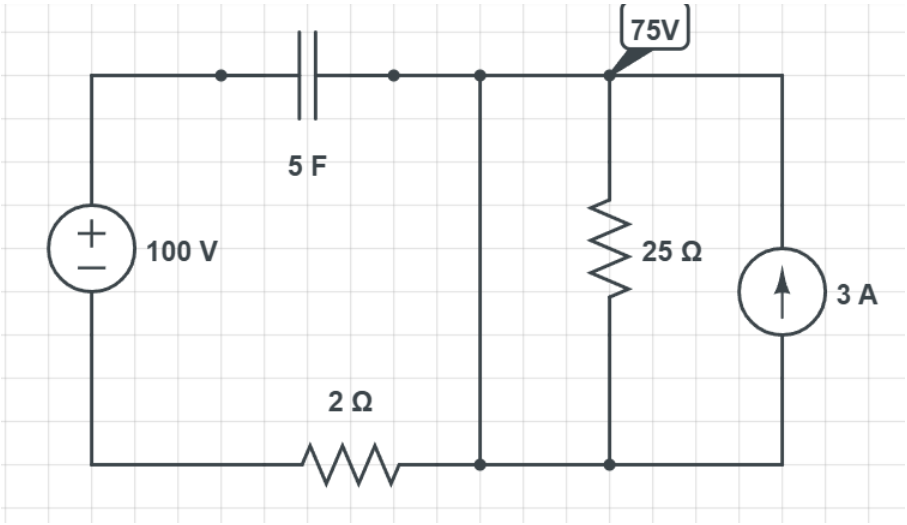
The integration of constant is linear function or triangular function.

Q9. At t < 0,



The voltage across capacitor = 100 – 75 = 25V, (Initial voltage)

After switch is closed, the 75V becomes 0,



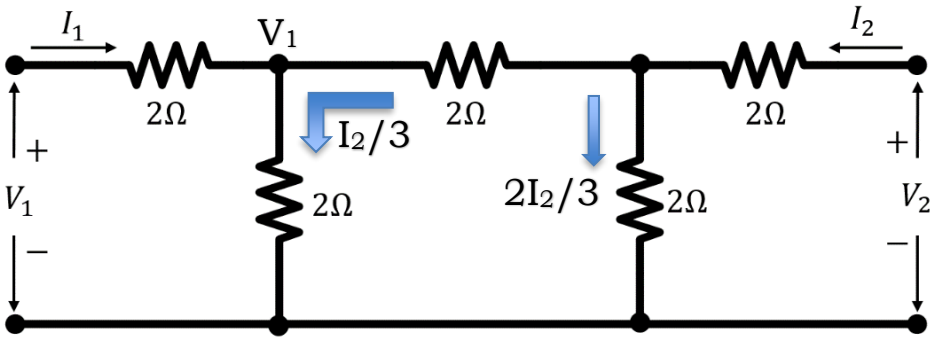
Voltage across the capacitor should rise to 100V,

Time constant τ = 10 seconds

$50 = 100 - [\ 100 - 25\ ]\ e^{-t/10}$

t = 4.054s

Q10.



Z_{in} with output open = $Z_{11} = Z_{22}$ due to symmetry.

$= 2 + 2 \,//(2 + 2) = 2 + 2 \times 4/6 = 10/3\ \Omega$

$Z_{12} = Z_{21} = V_1 / I_2$, when $I_1 = 0$

I_2 splits into 2Ω and $4\ \Omega$, which appears as V_1 across the $2\ \Omega$

$$V_1 = 2\Omega \times (I_2/3) , Z_{12} = Z_{21} = 2/3$$