MADE EASY

India's Best Institute for IES, GATE & PSUs

ESE 2019

Main Exam

Exam held on 30.06.2019

Electrical Engineering

Source of Questions from MADE EASY References

(Classroom/Books/Test Series)

Q.1 (a)

1.(a) Determine the eigen vectors of the matrix

$$\begin{bmatrix} -2 & 2 & -3 \\ 2 & 1 & -6 \\ -1 & -2 & 0 \end{bmatrix}$$

Show that those eigen vectors are linearly independent

Source: Made Easy Mains Workbook, Q.9 (Page 107)

Find the eigen values and eigen vectors of matrix $A = \begin{bmatrix} 3 & 1 & 4 \\ 0 & 2 & 6 \\ 0 & 0 & 5 \end{bmatrix}$.

Q.1 (b)

independent.

1.(b) Discuss superconductivity, superconducting materials and their applications.

1.(c) Find the f

Source: Made Easy Mains Test series offline Test-5, Q.1 (e)

What are type-I and type-II superconductors? Draw the magnetization versus magnetic field characteristic for type-I and type-II superconductors. Why superconductivity is observed for signals upto radio frequencies?

Q.1 (c)

materials and their applications. 12

1.(c) Find the force with which the plates of a parallel-plate capacitor attract each other. Also determine the pressure on the surface of the plate due to the field. 12

1.(d)

Source: Made Easy Theory Book EMT (Page 71 and 72)

Parallel - plate capacitor

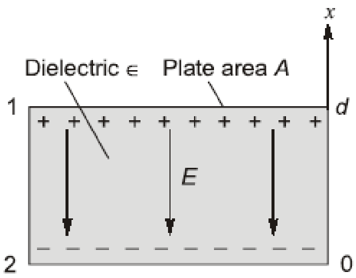


Figure 2.26 : *Parallel-plate capacitor*

Consider the parallel - plate capacitor shown in figure (2.26). Let the area of each plate is A and they are separated by a distance *d*. Assuming that plates 1 and 2 carry charges $+Q$ and $-Q$ uniformly distributed on them so that

$$\rho_s = \frac{Q}{S} \quad ...(2.133)$$

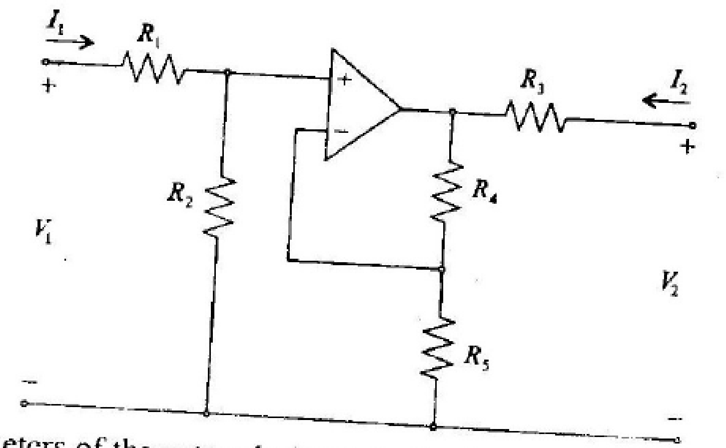
If the space between the plates is filled with a homogeneous dielectric with permittivity $\in$ and we ignore flux fringing at the edges of the plates, we have $\vec{D} = -\rho_s \hat{a}_x$ or

$$\vec{E} = \frac{\rho_s}{\in}(-\hat{a}_x) = -\frac{Q}{\in A}\hat{a}_x \quad ...(2.134)$$

Q.1 (d)

1.(d)

... surface of the plate due to the field. 12



Find the *z* parameters of the network shown in the figure. Is the network reciprocal ? If so why ? Assume the operational amplifier is ideal.

Source: Problem solved in Made Easy Classrooms

Q.1 (e)

1.(e) Volume charge density is the same as the divergence of the electric flux density. Using Gauss's law, derive equations to prove it. 12

Source: Made Easy Theory Book EMT (Page 33)

2.2 Gauss's Law - Maxwell's Equation

The total outward electric flux ψ through any closed surface is equal to the total charge enclosed by the surface.

In equation form, Gauss's law is written as

$$\psi = \oint_S \vec{D} \cdot d\vec{S} = Q_{enclosed} \quad \text{... (2.1)}$$

Where $d\vec{S} = \hat{a}_n dS$ and $\hat{a}_n$ is the outward pointing unit normal to closed surface S. Rewriting equation (2.1)

$$\psi = \oint_S \vec{D} \cdot d\vec{S} = \text{total charge enclosed } Q = \int_v \rho_v dv \quad \text{... (2.2 a)}$$

or,

$$Q = \oint_S \vec{D} \cdot d\vec{S} = \int_v \rho_v dv \quad \text{... (2.2 b)}$$

By applying divergence theorem to the middle term in Eq (2.2 b), we have

$$\oint_S \vec{D} \cdot d\vec{S} = \int_v \nabla \cdot \vec{D} dv \quad \text{... (2.3)}$$

Comparing the two volume integrals in Eqs (2.3) and (2.2 b) results in

$$\nabla \cdot \vec{D} = \rho_v \quad \text{... (2.4)}$$

Which is the first of the four Maxwell's equations to be derived.

Equation (2.4) states that the volume charge density is the same as the divergence of the electric flux density.

Q.2 (b)

2.(b)

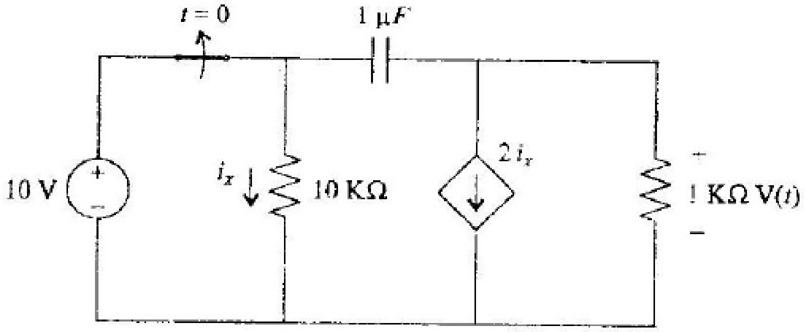
(i) State Hall effect and discuss the applications of Hall effect.

Source: Made Easy Mains Test series offline Test-12, Q.4 (a)

What is Hall effect? How it can be used to determine the carrier concentration in semi-conductors, explain with help of derivation?

Q.2 (c)

2.(c)

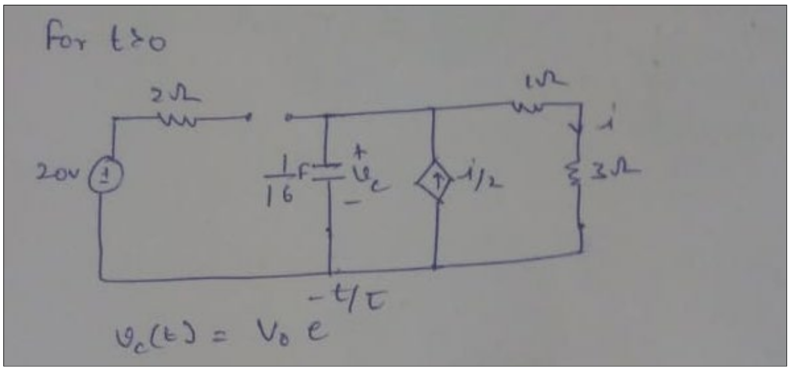


For the circuit shown in figure,

(i) Find the expression of $V(t)$, the voltage across 1kΩ resistor when the switch is opened at time $t = 0$.

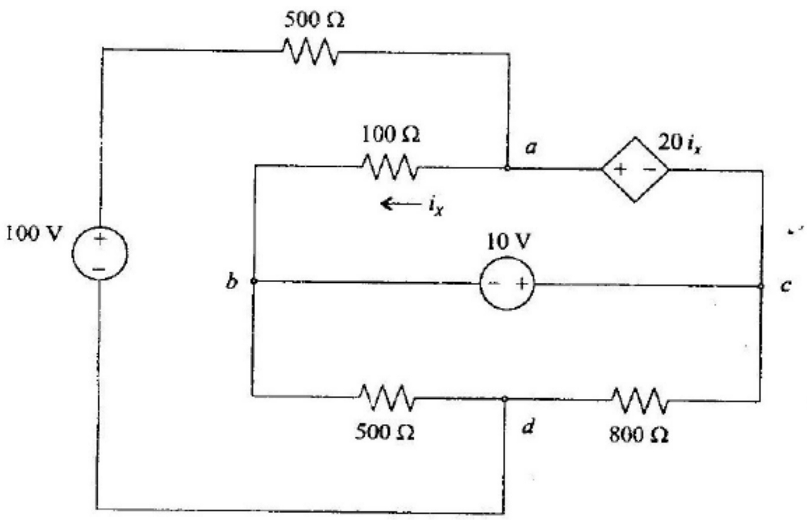
(ii) Sketch $V(t)$ with respect to time (t) and mark the time constant τ. 20

Source: Problem solved in Made Easy Classrooms



Q.3 (b)

3.(b)

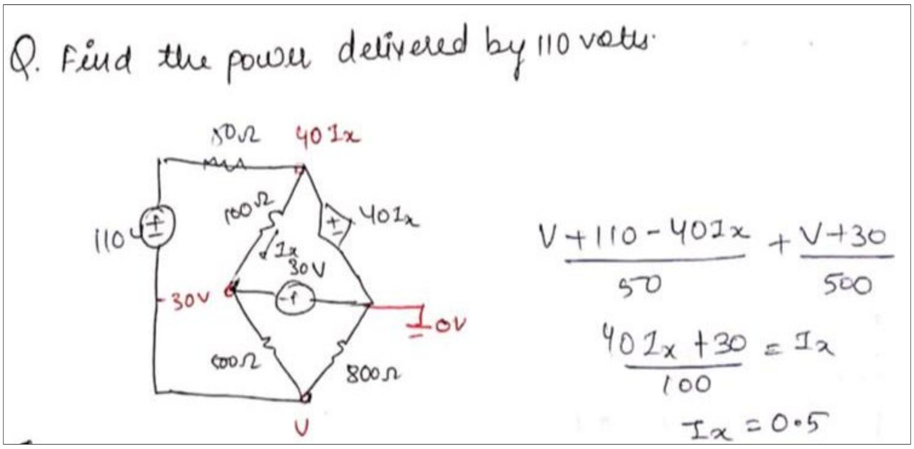


For the circuit shown in the figure,

(i) Find the node voltages.

(ii) Power absorbed by the 800Ω resistor. 20

Source: Problem solved in Made Easy Classrooms



Q.3 (c)

3.(c) List properties of ceramic materials and write their applications in technology. 20

Source: Made Easy Theory book Material Science (Page 118)

6.4 Insulating Materials

Ceramics

Ceramics are hard, strong, dense and brittle

- High temperature stability
- Generally inorganic materials
- They are non-metallic oxides, nitrides, carbides
- Generally crystalline materials (only exception is amorphous glass)

  Ex.: CdS, MgO, ZnO, garnets, $BaTiO_3$, cement, ferrites, SiC, TiO_2 (Rutile), ZnS, Quartz.

Types of Ceramics

(a) **Porcelain ($\epsilon_r < 12$):** It is used for low and high voltage applications. It is used as insulator in transmission and distribution system, plugs and sockets.

(b) **Steatite ($\epsilon_r < 12$):** It is used in high frequency application.

(c) **Alumina ($\epsilon_r < 12$):** Al_2O_3

- It is used in high temperature application.
- It is used in circuit breakers and resistance cores.

(d) **Titanate ($\epsilon_r > 12$):** High dielectric constant.

- It is used in capacitors.

Q.4 (a) (i)

4.(a) (i) An electrostatic field in xy-plane is given by $\phi(x, y) = 3x^2y - y^3$. Find the stream function ψ such that the complex potential $\omega = \phi + i\psi$ is an analytic function. 8

Source: Made Easy Mains Workbook, Q.48 (Page 133)

Question-48 If $u - v = (x - y)(x^2 + 4xy + y^2)$ and $f(z) = u + iv$ is an analytic function of $z = x + iy$, find $f(z)$ in terms of z.

Q.4 (a) (ii)

(ii) Find three Laurent's series expansions of the function $f(z) = \frac{\quad}{3z - z^2 - 2}$ and specify the regions in which those expansions are valid. 12

Source: Made Easy Mains Test series offline Test-8, Q.8 (b)

Find the Laurent's Series expansion of the function $\frac{z-1}{(z+2)(z+3)}$, valid in the region $2 < |z| < 3$.

Q.4 (b)

4.(b) What are magnetic materials ? Give classification of magnetic materials and name some materials in each class. 20

Source: Made Easy Mains Test series offline Test-7, Q.5 (e) (ii)

Differentiate between diamagnetic, paramagnetic, ferromagnetic and antiferromagnetic materials on basis of magnetic susceptibility, spontaneous magnetization and dipole arrangement.

Q.4 (c)

4.(c) (i) Show that in a source-free region ($J = 0$, $\rho_v = 0$), Maxwell's equations can be reduced to two. Identify the two all-embracing equations. 10

Source: Made Easy Mains Workbook, Q.26 (Page 66)

Show that in a source-free region ($\vec{J} = 0, \rho_v = 0$), Maxwell's equations can be reduced to two. Identify the two all-embracing equations.

Q.5 (a) (i)

5.(a) (i) Determine the possible base of the number in the operation mentioned below : 4

$23 + 44 + 14 + 32 = 223$

Source: Made Easy Mains Test series offline Test-1, Q.2 (c)

Each of the following arithmetic operation is correct in atleast one number system. Determine the possible bases in each operation.

(i) $3441 + 4235 = 7676$ **(ii)** $\frac{142}{7} = 16$

(iii) $23 + 44 + 14 + 32 = 223$ **(iv)** $21 \times 16 = 366$

(v) $\frac{302}{20} = 12.1$ **(vi)** $\sqrt{51} = 6$

Q.5 (a) (ii)

(ii) Find the minimal sum of products (SOP) expression of the following boolean function $f(a, b, c, d)$

$f(a, b, c, d) = abc + abd + a'bc' + cd + bd'$

where a', b', c' and d' are complements of variables a, b, c and d respectively. 4

Source: Made Easy Mains Test series offline Test-1, Q.3 (c) (ii)

Consider the Boolean expression $F(A, B, C, D) = \bar{A}\bar{B}D + \bar{A}CD + ABD + ABC$. If input combinations $ABCD = 0101, 1001, 1011$ are don't cares, then determine the simplified expression of F?

Q.5 (b)

A $4\frac{1}{2}$ digit and a $3\frac{1}{2}$ digit voltmeter on 10 V range are used for voltage measurements.

(i) Find the resolution of each meter.

(ii) How would the reading 0·7582 be displayed on these two meters ? 12

Source: Made Easy Mains Test series offline Test-9, Q.5 (e) and Made Easy Theory book Measurements Ex. 10.3 (Page 284)

A $4\frac{1}{2}$ digit voltmeter is used for voltage measurements:

(i) Find its resolution.

(ii) How would 12.98 V be displayed on a 10 V range?

(iii) How would 0.6973 be displayed on 1 V and 10 V ranges?

Example-10.3 A $4\frac{1}{2}$ digit voltmeter is used for voltage measurements.

(*i*) Find its resolution

(*ii*) How would 12.98 V be displayed on 10 V range?

(*iii*) How would 0.6973 be displayed on 1 V range?

(*iv*) How would 0.6973 be displayed on 10 V range?

Q.5 (c)

A 1000/5A, 50Hz current transformer at its rated load of 50 VA has an iron loss of 0·5 W and a magnetizing current of 8 A. Calculate the ratio error and phase angle when rated output is supplied to a meter whose resistance is 0·4 Ω and inductance is 0·7 mH. 12

Source: Made Easy Mains Workbook, Q.34 (Page 120)

Question-34 At its rated load of 25 VA, a 100/5 A current transformer has an iron loss of 0.2 W and a magnetizing current of 1.5 A. Calculate its ratio error and phase angle when supplying rated output to a meter having a ratio of resistance to reactance of 5.

Q.5 (d) (i)

5.(d)

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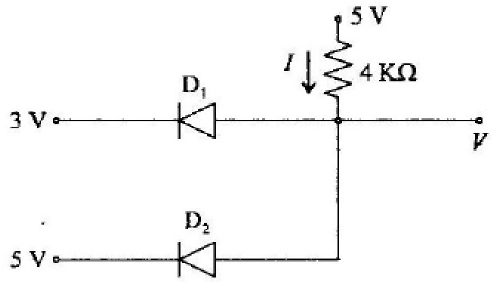
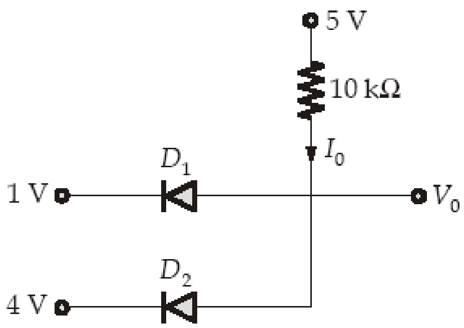


(i) For the circuit shown in the above figure using ideal diodes, find the values of the voltage V and current I indicated in the figure. 6

Source: Made Easy Prelims Test series offline Test-12, Q.3

Consider the circuit shown in the figure below:



If the diodes D_1 and D_2 are ideal, then the value of V_0 and I_0 are respectively

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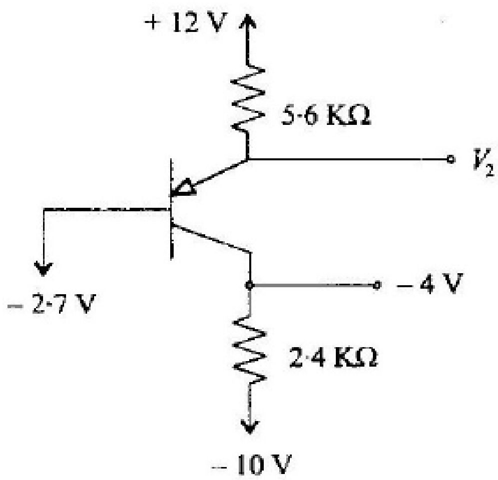
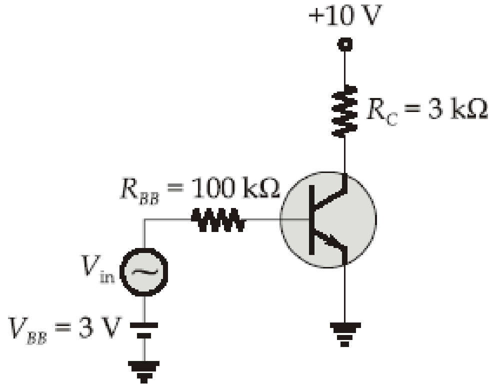
Q.5 (d) (ii)



(ii) For the circuits in the above figure assume that the transistor have very large β. Some measurements have been made on these circuits, the results are indicated in the figure. Find the values of the voltage V_2. 6

Source: Made Easy Mains Test series offline Test-14, Q.1 (d)

In the circuit shown below, determine the voltage gain of the transistor amplifier. (Take $\beta = 100$, $V_T = 25$ mV and draw the ac equivalent circuit).



Q.6 (b)

6.(b) In a single-phase power measurement test by three-voltmeter [...] the non-inductive readings were obtained. Across AC mains is 200 V; across the non-inductive resistance of 10 Ω is 110 V; across the load consisting of resistance (R) and inductance (L) is 120 V.

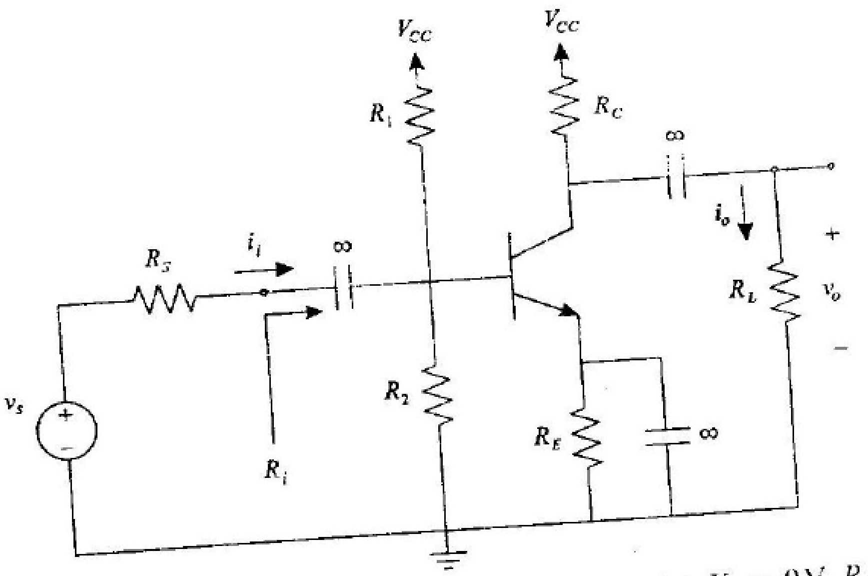
(i) Calculate the power supplied to the load.

(ii) Calculate the inductive reactance (X_L) and resistance (R) of the load. 20

Source: Problem solved in Made Easy Classrooms

Q.6 (c)

6.(c)

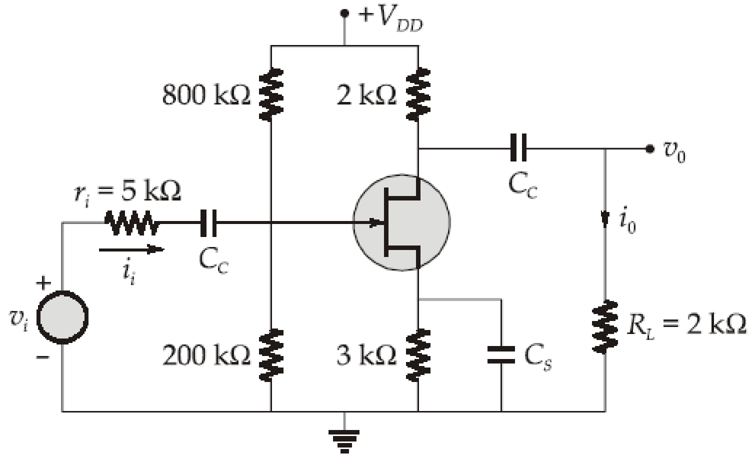


For the common-emitter amplifier shown in the figure, let $V_{CC} = 9\text{V}$, $R_1 = 27\text{K}\Omega$, $R_2 = 15\text{K}\Omega$, $R_E = 1{\cdot}2\text{K}\Omega$ and $R_C = 2{\cdot}2\text{K}\Omega$. The transistor has $\beta = 100$ and $V_A = 100\text{V}$ (V_A = Early Voltage). Calculate the dc bias current I_E. If the amplifier operates between a source for which $R_s = 10\text{K}\Omega$ and a load of $2\text{K}\Omega$ (R_L), replace the transistor with its hybrid-π model, and find the values of R_i and voltage gain v_o/v_s. 20

Assume $V_{BE} = 0{\cdot}7\text{V}$, V_T (thermal voltage) = 25 mV.

Source: Made Easy Mains Test series offline Test-6, Q.6 (b)

For the JFET amplifier shown in the figure below has g_m = 2 mS, r_i = 5 kΩ and r_{ds} = 30 kΩ. If C_C and C_S are large and the amplifier is biased in the pinch off region, find Z_{in}, $A_V = V_0/V_i$ and $A_I = i_0/i_i$.



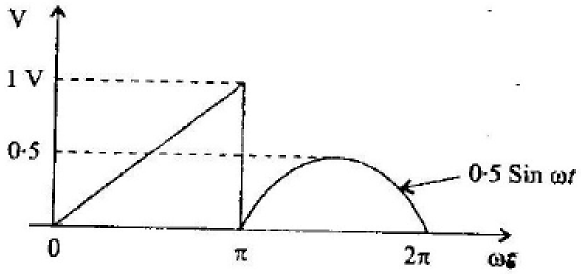
[20 marks]

Q.7 (b)

7.(b) Calculate the reading of

(i) Moving coil voltmeter

(ii) Moving iron voltmeter

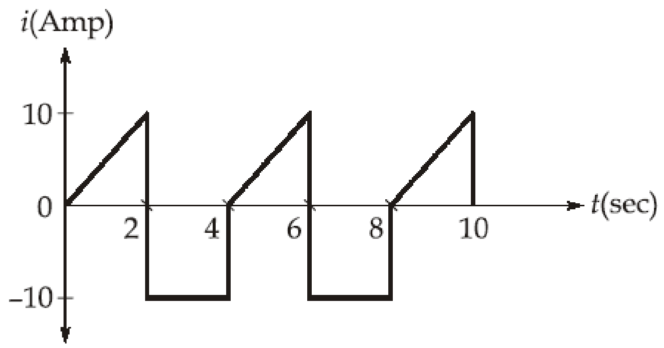


when these voltmeters are measuring the voltage of the waveform shown in the figure.

20

Source: Made Easy Mains Test series offline Test-3, Q.5 (b)

Determine the rms value of the waveform. If the current is passed through a 9 Ω resistor. Find the average power absorbed by the resistor.



Q.7 (c) (ii)

(ii) Explain the Barkhausen criterion for an oscillator circuit. How will the oscillator circuit's performance be affected if the Barkhausen criterion falls below 1, or goes much above 1 ?

8

Source: Made Easy Theory book Analog Electronics (Page 297)

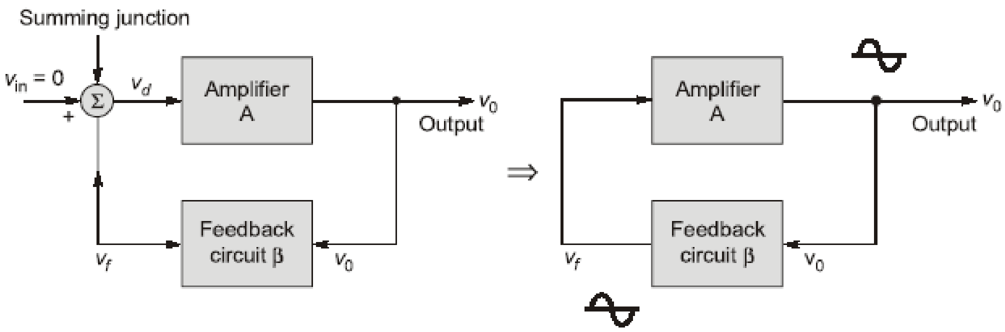


Figure-13.1 : *Oscillator block diagram*

In the block diagram of Fig. (13.1),

$$v_d = v_f + v_{in}$$
$$v_0 = A\, v_d$$
$$v_f = \beta v_0$$

using these relationships, the following equation is obtained:

$$\frac{v_0}{v_{in}} = \frac{A}{1 - A\beta}$$

However, $v_{in} = 0$ and $v_0 \neq 0$ implies that,

$$A\beta = 1 \qquad \text{...(13.1)}$$

Expressed in polar form

$$\boxed{A\beta = 1\angle 0° \text{ or } 360°} \qquad \text{...(13.2)}$$

Equation (13.2) gives two requirements for oscillation:

- the magnitude of the loop gain Aβ must be at least 1, and
- the total phase shift of the loop gain Aβ must be equal to 0° or 360°.

The condition given by equation (13.2) is known as ***Barkhausen criterion.***

Q.8 (a) (i)

8.(a) (i) Write a program in any programming language to sum of the following series up to N terms :

$$\lfloor 1 + \lfloor 2 + \lfloor 3 + \lfloor 4 + \lfloor 5 + \ldots\ldots + \lfloor N,$$

where $\lfloor N$ = factorial of N. 10

Source: Made Easy Mains Test series offline Test-9, Q.2 (a)

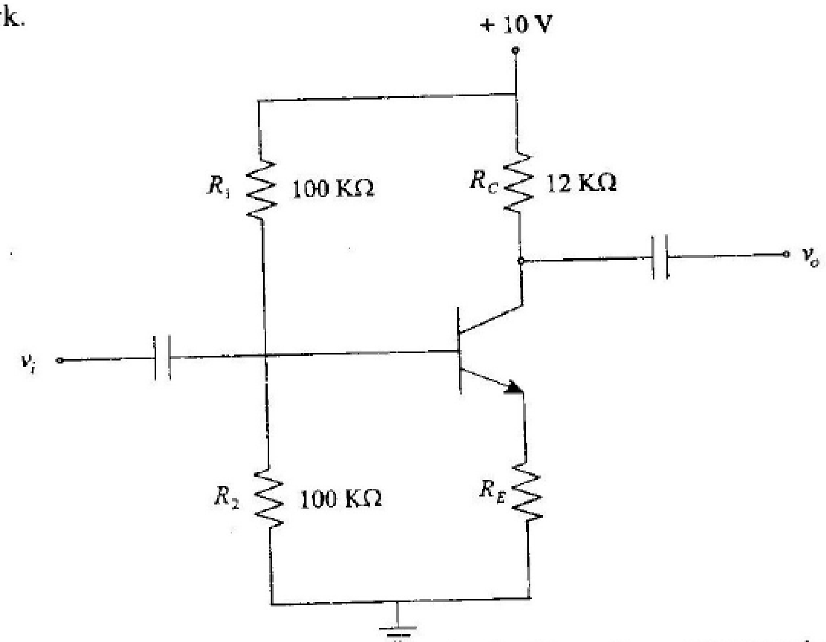
Write a C program to find the sum of sin x series:

$$x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \frac{x^9}{9!} - \frac{x^{11}}{11!} + \ldots$$

Q.8 (c)

network.

8.(c)



(i) Common emitter (CE) amplifier shown in the figure has voltage gain 400 when $R_E = 0$. Stability is brought through negative feedback by adding resistor R_E. Find the value of resistor R_E using feedback concepts so that final voltage gain is equal to 200. 10

(ii) Not all "zener" diodes breakdown in the exact same manner. Some operate on the principle of zener breakdown, while other operate on the principle of avalanche breakdown. How do the temperature coefficients of these two zener diode types compare ? Are you able to discern whether a zener diode uses one principle or the other just from its breakdown voltage rating ? Justify your answer. 10

Source: Made Easy Mains Test series offline Test-12, Q.1 (c)

A Silicon npn transistor operated with self bias gives $V_{CE\,Q} = 5$ V, $I_{CQ} = 2$ mA for $V_{CC} = 10$ V and $R_C = 2$ kΩ. If β for the transistor is 50, $V_{BE} = 0.7$ V and stability factor S is 5, then determine the values of biasing resistors R_1, R_2 and R_E.