वियोज्य *DETACHABLE*

ELECTRICAL ENGINEERING

Paper I

Time Allowed : Three Hours

Maximum Marks : 300

QUESTION PAPER SPECIFIC INSTRUCTIONS

Please read each of the following instructions carefully before attempting questions.

There are **EIGHT** questions divided in **TWO** Sections.

Candidate has to attempt **FIVE** questions in all.

Question Nos. **1** and **5** are **compulsory** and out of the remaining, **THREE** are to be attempted choosing at least **ONE** question from each Section.

The number of marks carried by a question / part is indicated against it.

Answers must be written in the medium authorized in the Admission Certificate which must be stated clearly on the cover of this Question-cum-Answer (QCA) Booklet in the space provided. No marks will be given for answers written in medium other than the authorized one.

Assume suitable data, if considered necessary and indicate the same clearly.

Unless otherwise mentioned, symbols and notations carry their usual standard meanings.

Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly. Any page or portion of the page left blank in the Question-cum-Answer Booklet must be clearly struck off.
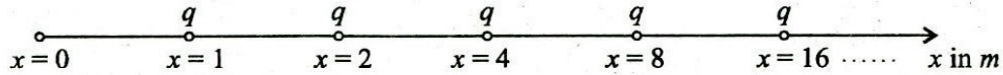
YLO-U-ELTE

SECTION 'A'

1.(a) Let $A = \begin{bmatrix} 5 & -2 & 0 \\ -2 & 6 & 2 \\ 0 & 2 & 7 \end{bmatrix}$ and $B = A^3 - 2A^2 - 5A + 6I$,

where I is the identity matrix, then calculate the determinant of B.   12

1.(b)

An infinite number of charges each equal to 'q Coulombs' are placed in a free space along the line at $x = 1$, $x = 2$, $x = 4$, $x = 8$, $x = 16$ and so on. Find the expression for potential and electric field intensity at point $x = 0$, due to these systems of charges. Assume that values of x are in metres.   12

1.(c) A Silicon diode that has an ohmic resistance of $0.5\ \Omega$ with reverse saturation current $I_0 = 10^{-12}$A and $\eta = 2.0$, consumes 50×10^{-12} W extra power compared to ideal diode. Diode operating temperature is $350°$K.

   (i) Determine the fraction of the applied voltage that falls across the ohmic resistance.

   (ii) Solve part (i), when diode current is 1A.

   (iii) Compare results of part (i) & (ii) and draw conclusion.   8+2+2

1.(d)
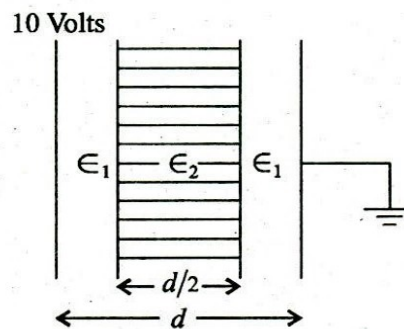
A parallel plate capacitor consisting of two dielectric materials is shown in figure. The middle dielectric slab is placed symmetrically with respect to the plates. If the potential difference between one of the plates and nearest surface of dielectric interface is 4 volts, determine $\dfrac{\epsilon_1}{\epsilon_2}$. Assume parallel plate capacitor has an electrode area of A m^2.   12

1.(e)

$$20 \text{ V}$$

$$D$$

$$G$$

$$I_{DSS} = 5 \text{ mA}$$

$$V_P = -4 \text{ V}$$

$$S$$
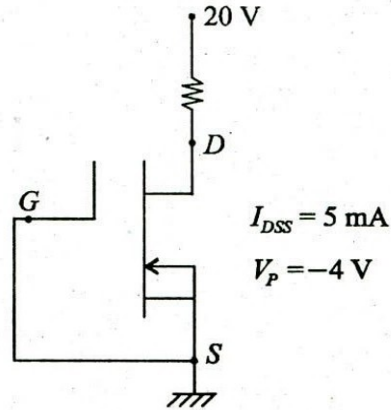
Write the equation related to the drain current (I_D) and Gate to source voltage V_{GS} explaining all the parameters for

(i) Depletion type MOSFET

(ii) Enhancement type MOSFET

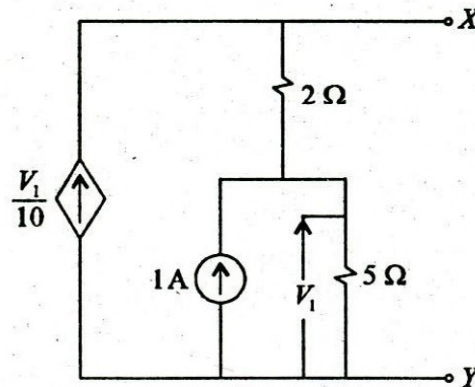(iii) Determine V_{DS} for the circuit shown in the figure.   4+4+4

2.(a)   Show that in the interval $(0, 1)$

$$\cos \pi x = \frac{8}{\pi} \sum_{n=1}^{\infty} \frac{n}{4n^2 - 1} \cdot \sin 2n\pi x$$

20

2.(b)

$$X$$

$$2\,\Omega$$
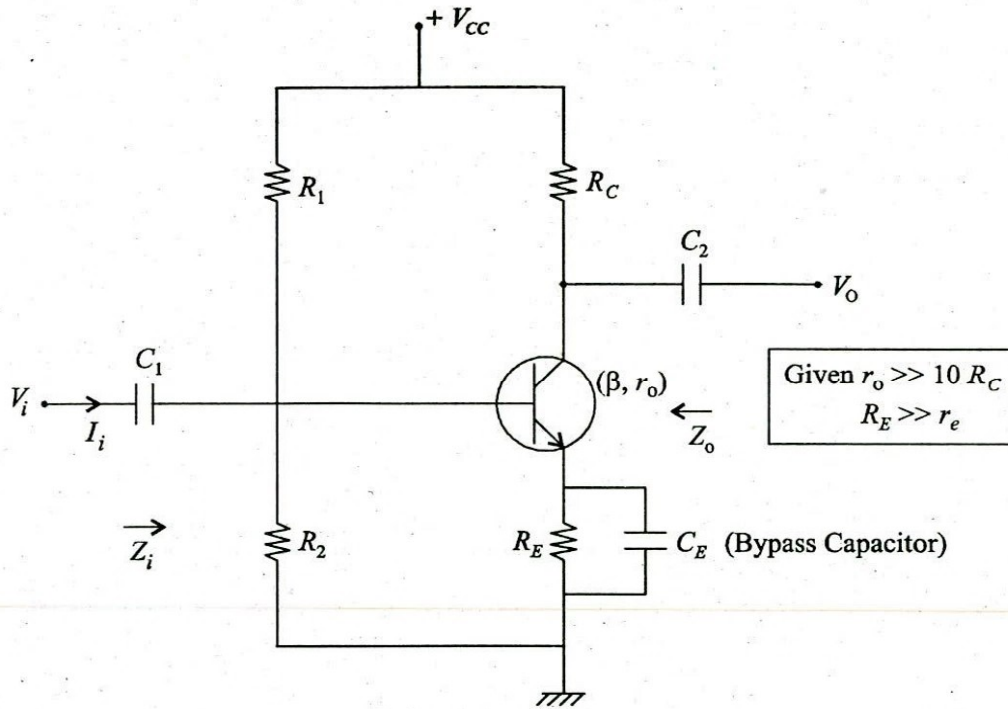
$$\frac{V_1}{10}$$

$$1A$$

$$V_1$$

$$5\,\Omega$$

$$Y$$

Determine the value of Load Resistance R_L to be connected across terminals X-Y to receive maximum power. Also, obtain the value of this maximum power.

20

3

2.(c)

Given $r_o \gg 10 R_C$
$R_E \gg r_e$

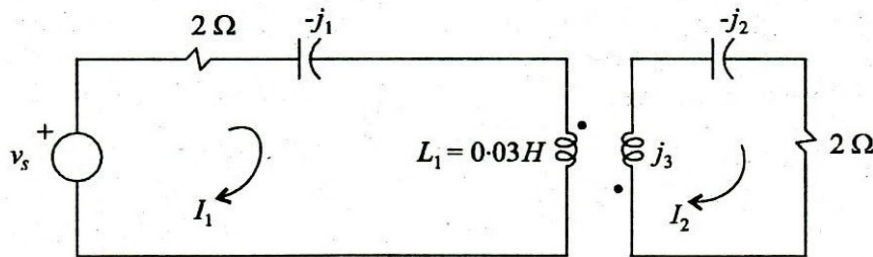Obtain the expression for voltage gain to given circuit.

(i) With bypass capacitor.

(ii) Without bypass capacitor.

(iii) Calculate voltage gain in part (i) & part (ii), if $R_1 = 90\ k\Omega$, $R_2 = 10\ k\Omega$, $R_E = 0.8\ k\Omega$, $\beta = 200$, $r_o = 50\ k\Omega$, $R_C = 2.2\ k\Omega$, and $V_{CC} = +15\ V$.
Compare both voltage gains and write conclusion in short.   5+5+10

3.(a)   Evaluate $\displaystyle\oint_C \frac{z^2 + 4z + 8}{\left(z - \frac{1}{2}\right)^2 (z^2 + 2z + 5)}\ dz$ where C is the contour $|z + 1 - i| = 2$ in anti-
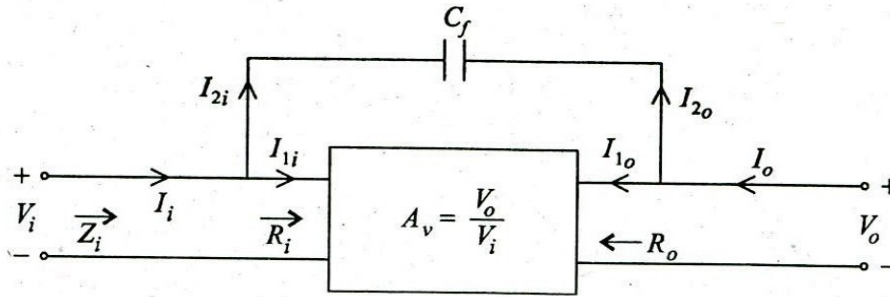
clockwise sense.   20

3.(b)

For the network shown, $v_s = 24\sqrt{2}\sin 100\,t$, coefficient of coupling $k = \frac{1}{3}$ between two coupled coils.

(i) Write loop equations in vector-matrix for currents I_1 & I_2.

(ii) Obtain the impedance seen by the source v_s and the power factor of the source.

          20

3.(c)

(i) Explain Miller effect capacitance in brief.

(ii) For the given circuit, prove that

    (A) Miller effect input capacitance
$$C_{M_i} = (1 - A_v)C_f$$

    (B) Miller effect output capacitance

$$C_{M_o} = \left(1 - \frac{1}{A_v}\right)C_f$$

    4+16

4.(a) Let the probability density function of a random variable X be given as :

$$f(x) = \frac{5}{3}e^{-5x}u(x) + \beta e^{2x}u(-x)$$

where β is a constant and $u(x)$ is the unit step function. Calculate :
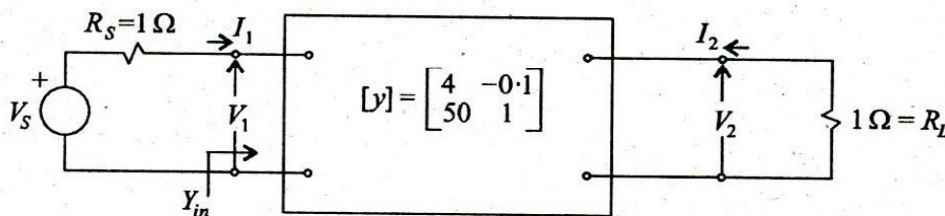
(i) The value of β

(ii) Mean of X

(iii) Variance of X

    3+7+10

4.(b)

For the two port network shown, the y-parameter matrix is given.

(i) Obtain the input admittance Y_{in} as shown in the figure.

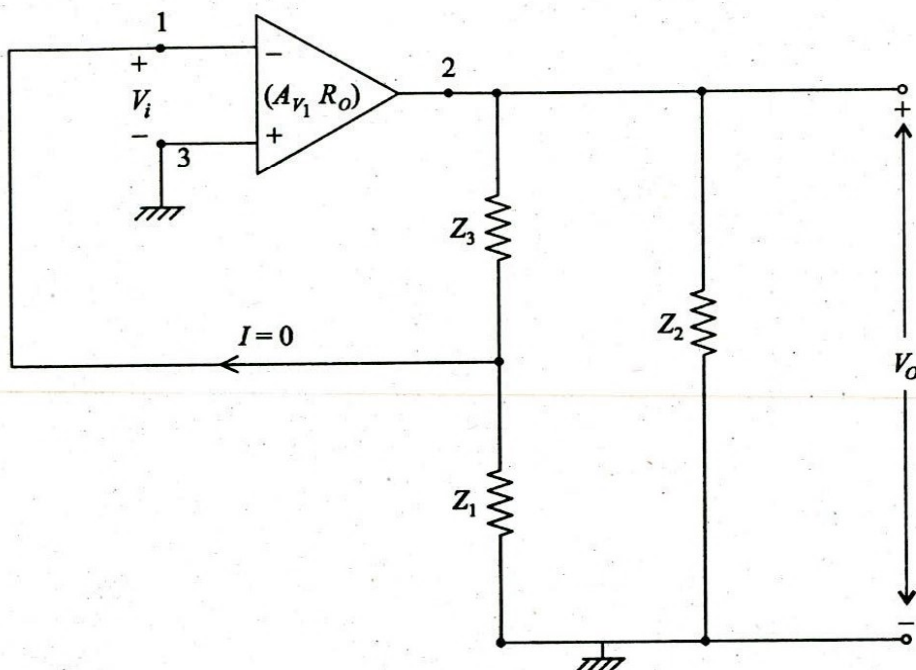(ii) Obtain voltage gain $\frac{V_2}{V_s}$.

    20

5

4.(c) (i) State whether the given statement is true or false for practical oscillators with reasons.

"Loop gain is generally made slightly larger than unity."

(ii) In a general form of oscillator circuit given in figure.

Given Impedances Z_1, Z_2 and Z_3 are purely reactive.

Prove that if Z_1 and Z_2 are capacitors then Z_3 must be an inductor and vice versa.   5+15

SECTION 'B'

5.(a) Mention the type of Bravais space lattice, relationship of crystal axial lengths (x, y, z) and relationship of interaxial angles (α, β, γ) in the following order of the crystal system.

  (i) Triclinic

  (ii) Monoclinic

  (iii) Orthorhombic and

  (iv) Trigonal   12

5.(b) A standard cell of 1·0185 V used with a simple potentiometer balances at 50 cm. Calculate

  (i) the emf of cell which balances at 72 cm

  (ii) the percentage error in voltmeter which balances at 64·5 cm when reading 1·33 V

  (iii) Percentage error in an ammeter that reads 0·43 A and balance is obtained at 43·2 cm with Pd across a 2Ω resistor in the ammeter circuit.   12

5.(c) (i) Write down algorithm in Pseudocode for sorting an array in descending order. Specify the name of the algorithm you have used. **6**

(ii) Write a program segment in any higher level language for Linear search problem. (Specify which language you are using.) **6**

5.(d) A non-inductive shunt is used to increase the range of a 10 A moving iron ammeter to 100 A. The impedance of the instrument including the leads is $(0.06 + j\,4.71\times10^{-3})\Omega$. If the combination is correct on a dc circuit, find the error on ac circuit. **12**

5.(e) (i) Explain the electrochemical breakdown in insulators and discuss any two factors that accelerates the breakdown. **8**

(ii) A magnetic material having almost a square hysteresis loop has a coercivity of 50 A/m and a remanence of 0.5 T. If this material is used in a toroidal inductor of mean diameter 1.6 cm, with a cross-sectional area of $0.25\times10^{-4}\,m^2$, calculate the power loss at a frequency of 50 Hz when the material is driven around one complete hysteresis cycle. **4**

6.(a) (i) Explain electrical resistivity of metals in terms of thermal and residual components. Also draw the schematic variation of them with respect to temperature. **8**

(ii) Write the relation between magnetic susceptibility and temperature according to Curie Law, Curie-Weiss Law and Neel Law. Sketch the variation of reciprocal of susceptibility with temperature as per the above laws. **6**

(iii) What are ferrites ? Mention 3 disadvantages. State the reason, why ferrites are suitable for high frequency operation. **6**

6.(b) (i) Prove that the most probable value is the mean value. **6**

(ii) What is an RS-232 interface ? How many signals it can handle ? How many wires are sufficient for operation ? **6**

(iii) What is creeping in energy meters ? State the reasons for the same and how it is avoided. **8**

6.(c) (i) Can we use Semiconductor Memory for secondary storage ? Justify your answer. **5**

(ii) What exactly is the role of Control Unit in CPU ? How is it different from that of an Arithmetic Logic Unit ? **6**

(iii) How exactly is an array stored in main memory ? Illustrate with the help of storage of a matrix. What will be the exact address of element $A(3, 7)$ of an 8×9 array A assuming that location of the first element is d. **9**

7.(a) (i) Supporting with suitable figures, define initial permeability and maximum permeability. Mention the approximate range of values for iron. Mention one importance each of initial and maximum permeabilities. **8**

(ii) Specific gravity of a ceramic is 3.2 g/cm³. Calculate the percentage apparent porosity and percentage true porosity with the following data :
Ceramic when weighed dry = 360 g
Ceramic when weighed after soaking in water = 385 g
Ceramic weighed while suspended in water = 224 g **6**

(iii) What is photo-conductivity ? Discuss the factors that are to be considered for the selection of photo-conduction material. **6**

7.(b)
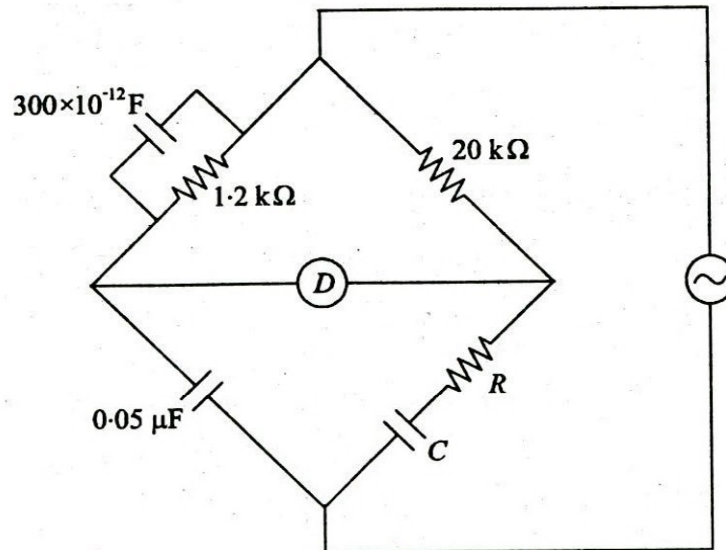
For the bridge circuit shown determine the values of R and C. Derive the formula used. 20

7.(c)   (i) How is Division exactly done by ALU ?   7
         (ii) Prove with illustration that NAND is a "Universal Gate".   6
       (iii) How will you implement a two-way switch using minimum number of logic gates ?   7

8.(a)   (i) Explain the Top-Bottom and Bottom-Up approach to produce the nanostructure. Name the methods used in each case to produce nanomaterial. 8

       (ii) The current measured in a superconducting ring by 0.01% accuracy meter after one year shows no decay of current. If there are 10^{28} electrons/m^3, calculate the conductivity. How many times larger is this conductivity than that of copper of resistivity $1.724 \times 10^{-8} \Omega$m. 8

      (iii) Addition of 0.25 atomic percent nickel and 0.4 atomic percent silver into copper at 298 K increases the resistivity by $0.012\ \mu\Omega$cm and $0.016\ \mu\Omega$m respectively. If the resistivity of copper is $0.015\ \mu\Omega$m at 298 K, determine the conductivity of the resulting alloy. 4

8.(b) The power consumed by a single phase 11 kV load taking 100 A at 0.5 powerfactor lagging is measured on a dynamometer wattmeter used in conjunction with potential transformer (PT) and current transformer (CT). Determine the reading of the wattmeter considering the following data :
     Nominal ratio of PT and CT are $100 : 1$ and $20 : 1$
     Ratio error of PT and CT are $+0.8\%$ and -0.2%
     Phase angle errors of PT and CT are $+42$ minutes and $+90$ minutes.
     Phase angle of the pressure coil due to its inductance is 30 minutes.   20

8.(c)   (i) Is the use of Virtual Memory advisable for Real Time Systems ? Justify briefly your answer. 7
       (ii) Compare briefly and precisely the LINUX OS with Windows-NT OS.   5
      (iii) For File Management how does a DBMS help ?   8