Engineering Services (Main)
Examination, 2026

वियोज्य *DETACHABLE*

ELECTRONICS AND TELECOMMUNICATION 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.

Questions No. **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.

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Diagrams/Figures, wherever required, shall be drawn in the space provided for answering the question itself.

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.

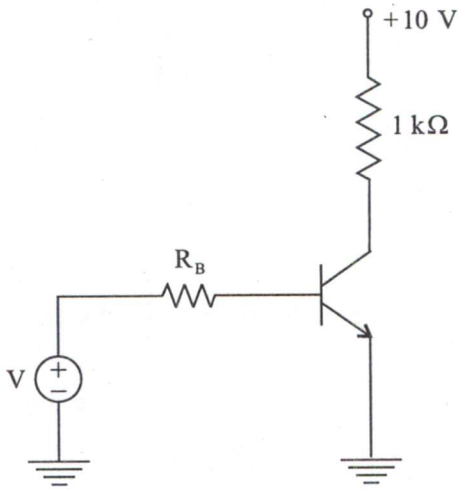
Answers must be written in **ENGLISH** only.

Values of constants which may be required :

Electron charge	$= -1{\cdot}6\times10^{-19}$ Coulomb
Free space permeability	$= 4\pi\times10^{-7}$ Henry/m
Free space permittivity	$= (1/36\pi)\times10^{-9}$ Farad/m
Velocity of light in free space	$= 3\times10^{8}$ m/sec
Boltzmann constant	$= 1{\cdot}38\times10^{-23}$ J/K
Plank's constant	$= 6{\cdot}626\times10^{-34}$ J-s

SECTION 'A'

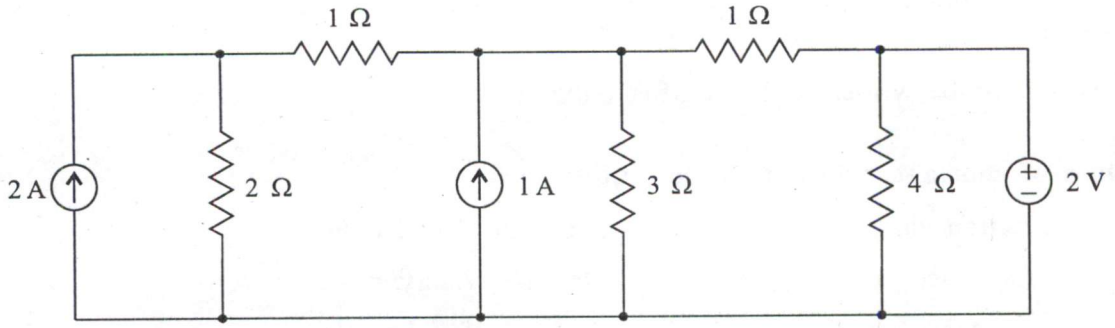
1.(a) Consider a BJT transistor amplifier with transistor parameters $\beta = 100$, $V_{BE} = 0{\cdot}7$ V and $R_B = 100\ k\Omega$. Find the range of input voltage V for the transistor to operate in active region. 12



1.(b)(i) If the band gap of a semiconductor is 1·8 eV, what are the frequency and momentum of the photon that is emitted ? 4

1.(b)(ii) If one makes an LED in a semi-conductor with a band gap of 2·5 eV, what wavelength of light will it emit ? Can you use it to efficiently detect photons of wavelengths 1900 nm and 100 nm ? 8

1.(c) Find the power delivered by the current sources shown in the Figure and the total power loss in the circuit. 12



1.(d) Describe the technical, environmental and economic constraints of offshore versus onshore wind energy and propose strategies to improve the capacity factor and stability of wind power in national electricity grid. 12

1.(e) The three different crystallographic planes for a unit cell of a hypothetical metal are described as :

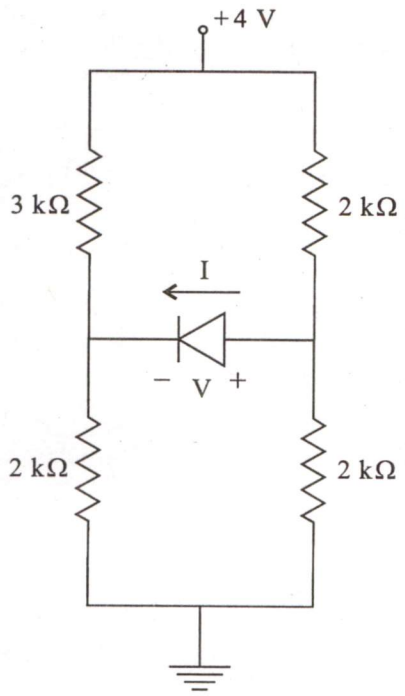
(i) The plane (001) has dimensions 0·40 nm and 0·40 nm and atoms are at corners only.

(ii) The plane (100) has dimensions 0·40 nm and 0·55 nm and atoms are at corners only.

(iii) The plane (110) has only one dimension known and its value is 0·55 nm. This plane has atoms at all four corners and also at the centre of plane.

Identify the crystal structure of this hypothetical metal. 12

2.(a) Determine the Q-point of the diode shown in figure using :



(i) the ideal diode model

(ii) the constant voltage drop model with $V_{on} = 0{\cdot}6$ V

Which model do you feel to be more realistic ? Justify your answer. 20

2.(b)(i) Draw the speed-load characteristics of D.C. shunt motor, series motor and cumulative compound motor. Explain the shape of each motor characteristics to suit specific application. 10

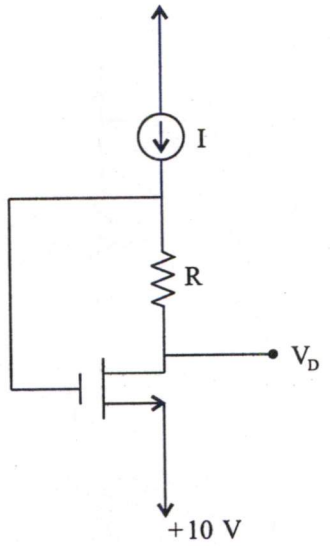
2.(b)(ii) A 25 kW, 125 V separately excited D.C. machine is operated at a constant speed of 1500 rpm with a constant field current such that the open circuit armature voltage is 125 V. The armature resistance is 0·02 ohm. Compute the terminal power, electromagnetic power and torque when the terminal voltage is 128 V and 124 V. State in which case the D.C. machine is operating as a motor. 10

2.(c)(i) Estimate the theoretical density of CaF_2, if atomic weight of 'Ca' and 'F' are 40·080 and 18·998 g/mole, respectively. The radii of Ca^{++} and F^- ions are 0·100 nm and 0·133 nm, respectively. 15

2.(c)(ii) Discuss tape casting technique for ceramic fabrication. 5

3.(a)(i) For a MOSFET with $V_T = 1$ V and $W = 50$ μm, $L = 2$ μm, calculate the drain current at $V_G = 5$ V, $V_D = 0{\cdot}1$ V. Repeat for $V_G = 3$ V, $V_D = 5$ V. Assume an electron mobility $\mu_n = 200$ cm^2/V$_s$ and the substrate is connected to the source. W is the width of the channel, L is the length of the channel (i.e. from source to drain). Assume the insulator capacitance to be $3{\cdot}452 \times 10^{-7}$ F/cm^2. 10

3.(a)(ii) In the MOSFET circuit shown below, the transistor has k'_n W/L = 0·2 MA/V^2, $\lambda = 0$ and $V_T = 1$ V. The current source has current I = 50 μA.



(A) For R = 10 KΩ, find the gate-source voltage V_{GS}, the drain voltage V_D and the state in which region the transistor operates.

(B) Find R so that the transistor operates in the triode region with $V_{DS} = 0{\cdot}5$ V.

Where, $\frac{W}{L}$ is the ratio of width to the length of the channel. 10

3.(b)(i) An A.C. source of 50 Hz is supplied to a 100 kW single phase motor. If the terminal voltage of the motor is $230\angle 0°$ volts, the p.f. of the motor is 0·5 lag, the interconnecting cable of the voltage source and motor is having 0·1 ohm resistance, find the source power. 10

3.(b)(ii) Why must slip be present for an induction motor ? The induction motor cannot run at synchronous speed, justify. 10

3.(c) Gallium atoms are to be diffused into silicon for developing a semiconducting device. The pre-deposition heat treatment is to be conducted at 1100°C for 4 hrs. The desired gallium concentration at a depth of 1 μm is 2×10^{22} atoms/m^3. Assuming the surface concentration of gallium remains constant and the background concentration of gallium to be 2×10^{19} atoms/m^3, calculate the required surface concentration of gallium.

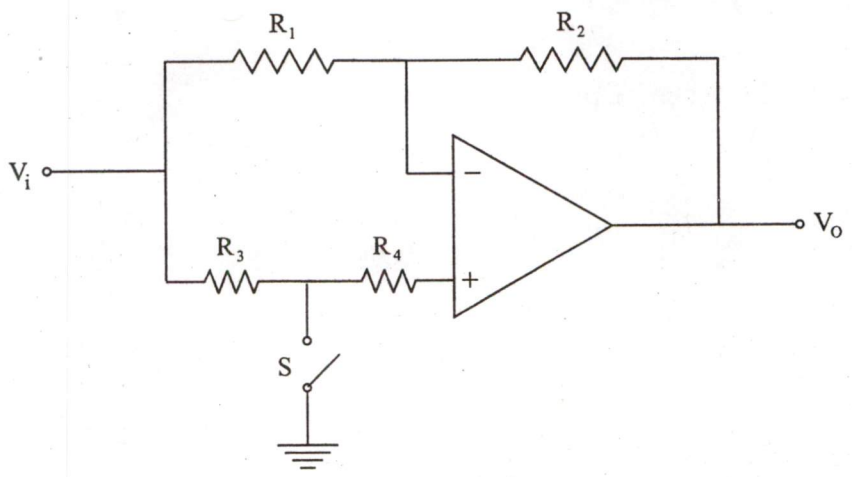
Given :

Diffusion coefficient (D_o) = $3{\cdot}74\times10^{-5}$ m^2/s
Activation energy value = 3·39 eV/atom
Boltzmann's constant k = $8{\cdot}62\times10^{-5}$ eV/atom-K
erf (1·0) = 0·8427
erf (1·1) = 0·8802
erf (1·2) = 0·9103
erf (1·3) = 0·9340 20

4.(a)(i) Determine the ratio of output to input voltages, when

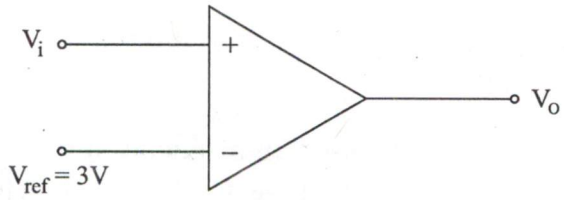
(A) switch 'S' is open

(B) switch 'S' is closed



Assume the op-amp to be ideal. 10

4.(a)(ii) If the input to the ideal comparator shown in figure is a sinusoidal signal of 12 V (peak to peak) without any D.C. component, find the duty cycle of the output of the comparator. Also sketch the output clearly showing all the labels. 10



4.(b)(i) Derive the expression for the induced e.m.f. of a transformer. 5

4.(b)(ii) A 500 KVA, 50 Hz, 440/11000 V, 1-phase transformer has an efficiency of 98·5% when supplying full-load current at 0·8 power factor lagging and an efficiency of 99% when supplying half full load current at unity power factor. Find the core losses and copper losses corresponding to full-load current. At what value of load current will the maximum efficiency be attained ? 15

4.(c)(i) (A) Classify the methods of nanoparticle synthesis on the basis of different approaches. 5

(B) How nanoparticles are purified and what are the challenges during purification. 5

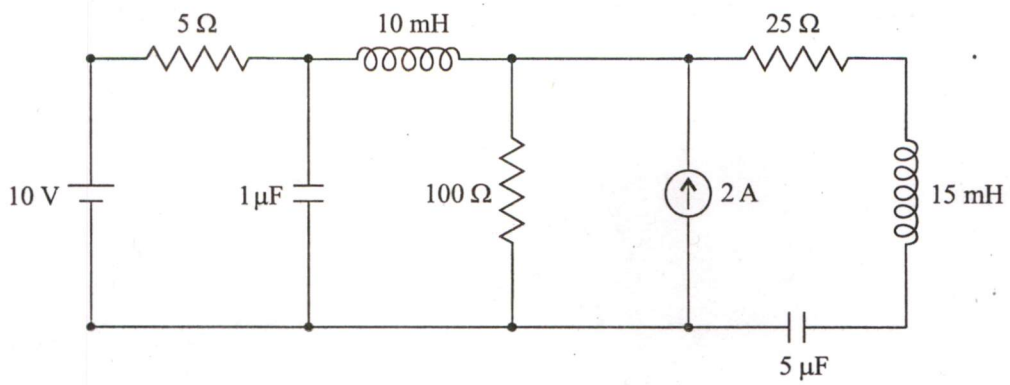
4.(c)(ii) Classify magnetic materials on the basis of the occurrence of permanent atomic magnetic dipoles and their interactions. 5

4.(c)(iii) Classify the types of polarization in insulators. 5

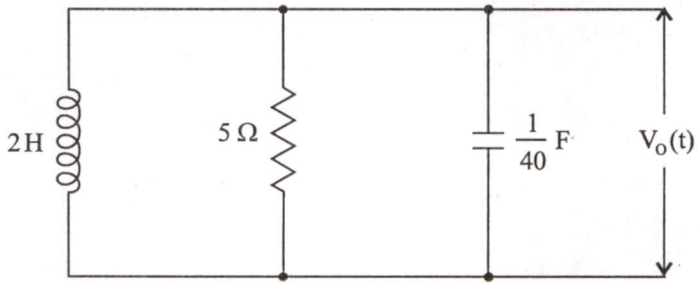
SECTION 'B'

5.(a) A shunt ammeter using a basic meter movement with an internal resistance of 2000 Ω and a full scale deflection current of 100 μA is connected in a circuit and gives reading of 2·5 mA on its 5 mA scale. The reading is checked with a recently calibrated D.C. ammeter which gives a reading of 4·1 mA. The implication is that the ammeter has a faulty shunt on its 5 mA range. Calculate the actual value of faulty shunt and the current shunt for the 5 mA range. 12

5.(b) For the network shown in figure below, (i) Draw the oriented graph and develop the reduced incidence matrix and tie-set matrix, (ii) Find the number of possible trees. 12



5.(c) For the circuit shown in figure below, determine the expression for the output voltage $V_o(t)$, if the initial current flow through the 2H inductor is 1A and initial voltage across the $\frac{1}{40}$F capacitor is 10 V. 12



5.(d) A certain eight bit D/A converter has a full-scale output of 5 mA and a full-scale error of ±0·25% of full scale. Determine the range of expected analog output for a digital input of 10000010. 12

5.(e) The logic function of a 3-input logic gate is defined by

$$F(A,B,C) = \overline{A}\,\overline{B} + \overline{B}\,\overline{C} + \overline{A}\,\overline{C}$$

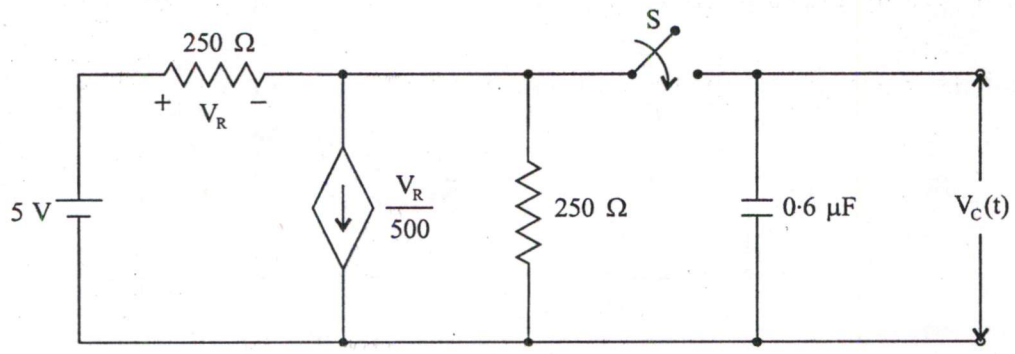
where, A, B and C are logic inputs of the gate. Determine and realize the following logic function

$$W(A,B,C) = F\left(F(\overline{A},\overline{B},\overline{C}), F(A,B,\overline{C}), \overline{C}\right)$$ 12

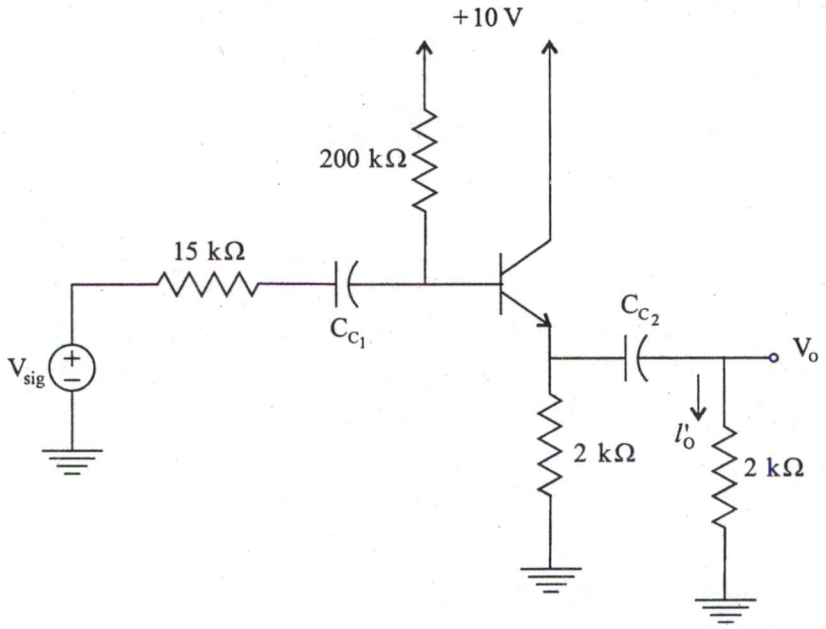
6.(a)(i) What are the advantages and disadvantages of electrodynamometer type instruments ? 10

6.(a)(ii) A 100 V range spring controlled electrodynamic voltmeter has an initial inductance of 0·25 H, the full scale deflection torque of $0{\cdot}4\times10^{-4}$ N.m and full scale deflection current of 50 mA. Determine the difference between D.C. and 50 Hz A.C. reading at 100 V if the voltmeter inductance increases uniformly over the full scale of 90°. 10

6.(b) In the circuit shown in figure below, the switch 'S' is closed at time t = 0, while the capacitor is initially charged to –5 V [that is $V_c(0^-) = -5$ V]. Compute the time taken for the capacitor voltage to reach to 0 V, (that is, zero volt). 20



6.(c) The BJT in the emitter-follower amplifier in the figure has β = 100. The coupling capacitors may be taken as short circuits at the signal frequencies. Neglect the output resistance of the transistor.



Find :

(i) the bias value of the emitter voltage V_E

(ii) the value of r_π

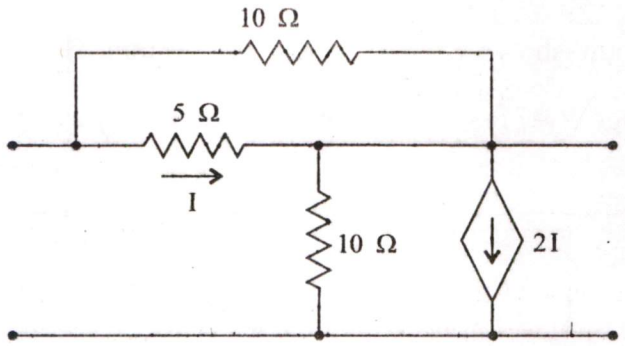
(iii) the value of g_m

(iv) the value of collector current 20

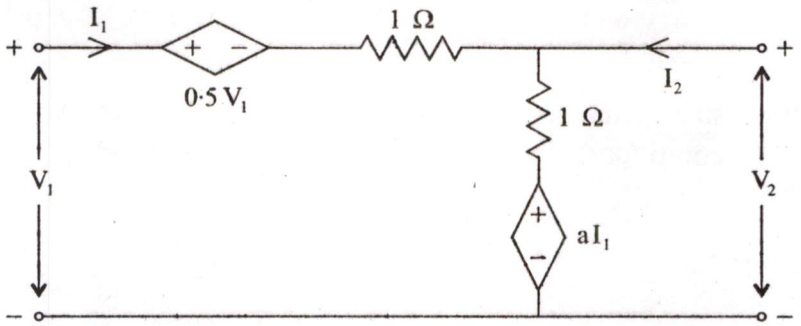
7.(a)(i) State the different functions of driver software of a typical Data acquisition system. 10

7.(a)(ii) A CRT has an anode voltage of 2500 V and 4 cm long and 7 mm apart parallel deflecting plates. The screen is 50 cm from the centre of the plates. Find the input voltage required to deflect the beam through 6 cm. The input voltage is applied to the deflecting plates through amplifiers having an overall gain of 200. 10

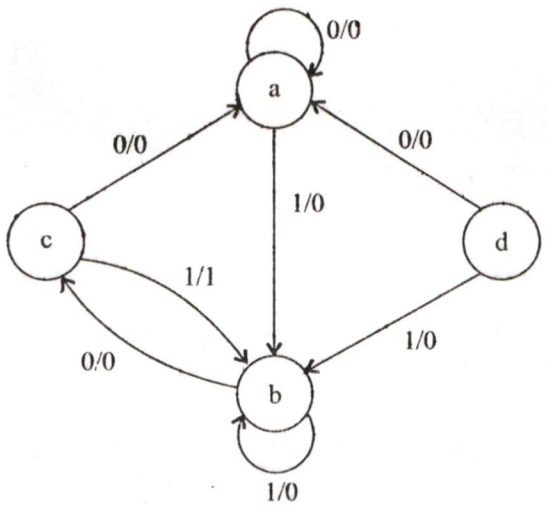
7.(b)(i) Find the z parameters for the two port network shown in figure below : 10



7.(b)(ii) Determine the value of a for which the two port network shown in figure below is reciprocal. 10



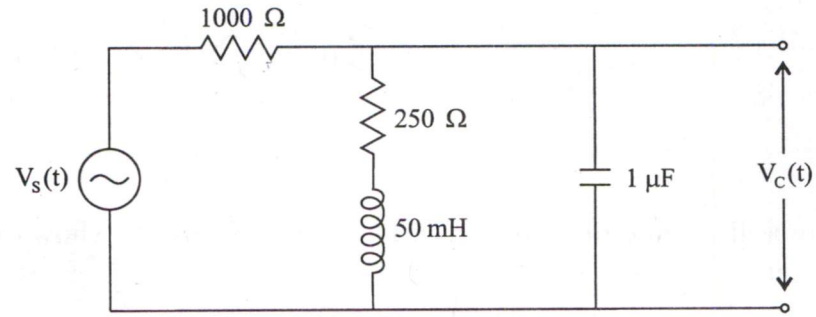
7.(c) Design a clocked sequential machine using J-K flip-flops for the state diagram shown in figure below. 20



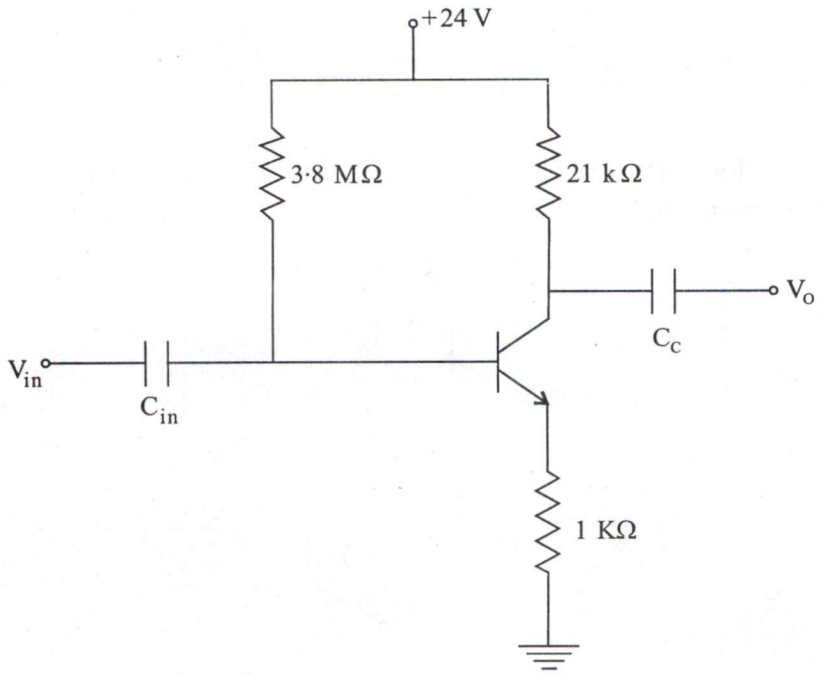
8.(a)(i) Explain why is it essential to use Radio Frequency telemetry. Describe it with some relevant examples. 15

8.(a)(ii) A broadcast A.M. transmitter radiates 100 kW of carrier power. What will be the radiation power at 90 percent of modulation ? 5

8.(b) For the circuit shown in figure below, determine the expression for steady state output voltage $V_c(t)$ for the sinusoidal source voltage of $V_s(t) = 120 \cos (5000\, t + \frac{\pi}{3})$ 20



8.(c)(i) The transistor in the feedback circuit shown below has $\beta = 200$. In the transistor, under the conditions of operation, V_{BE} may be assumed to be negligible.



Find the voltage gain of the circuit with and without feedback. 10

8.(c)(ii) The diagram shown below is a discrete circuit of a two input transistor – transistor logic (TTL) NAND gate. Calculate the output voltage (V_o), when both inputs *A* and *B* are low. Assume $V_{CE(sat)} = 0{\cdot}1$ V, and diode voltage 0·7 V. 10