SECTION - A

1. For each of the following questions (1.1 – 1.47), 4 alternatives, A, B, C and D are given. Indicate the correct or the best answer by writing the corresponding lable, A, B, C or D in CAPITALS against each question number.

1.1 A DC voltage source is connected across a series R-L-C circuit. Under steady-state conditions, the applied DC voltage drops entirely across the

(a) R only (b) L only (c) C only
(d) R and L combination

1.2 Consider a DC voltage source connected to a series R-C circuit. When the steady state reaches, the ratio of the energy stored in the capacitor to the total energy supplied by the voltage source, is equal to

(a) 0.362 (b) 0.500 (c) 0.632 (d) 1.000

1.3 Two 2H inductance coils are connected in series and are also magnetically coupled to each other the coefficient of coupling being 0.1. The total inductance of the combination can be

(a) 0.4 H (b) 3.2 H (c) 4.0 H (d) 3.3 H

1.4 The RMS value of a rectangular wave of period T, having a value of +V for a duration, $T_1 \left(< T\right)$ and –V for the duration, $T - T_1 = T_2$, equals

(a) V (b) $\frac{T_1 - T_2}{T} V$ (c) $\frac{V}{\sqrt{2}}$ (d) $\frac{T_1}{T_2} V$

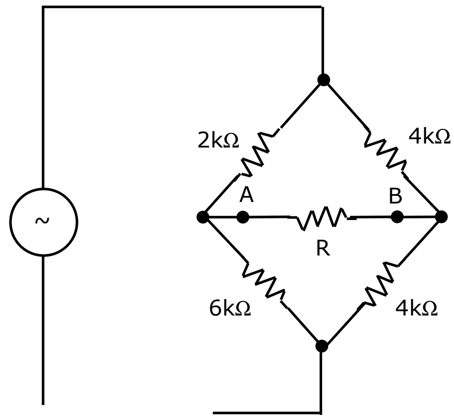
1.5 If $L\left[f\left(t\right)\right] = \frac{2\left(s+1\right)}{s^2 + 2s + 5}$, then $f\left(0+\right)$ and $f\left(\infty\right)$ are given by

(a) 0, 2 respectively (b) 2, 0 respectively

(c) 0, 1 respectively (d) $\frac{2}{5}$, 0 respectively

Note: 'L' stands for 'Laplace Transform' of]

1.6 The value of the resistance, R, connected across the terminals, A and B, (ref. figure), which will absorb the maximum power, is



(a) 4.00 kΩ (b) 4.11 kΩ (c) 8.00 kΩ (d) 9.00 kΩ

1.7 The current, $i(t)$, through a 10Ω resistor in series with an inductance, is given by

$i(t) = 3 + 4\sin(100t + 45°) + 4\sin(300t + 60°)$ Amperes

The RMS value of the current and the power dissipated in the circuit are:

(a) $\sqrt{41}A$, 410 W, respectively (b) $\sqrt{35}A$, 350 W, respectively

(c) 5A, 250 W, respectively (d) 11A, 1210 W, respectively

1.8 Signal flow graph is used to find

(a) stability of the system (b) controllability of the system

(c) transfer function of the system (d) poles of the system

1.9 The step error coefficient of a system $G(s) = \frac{1}{(s+6)(s+1)}$ with unity feedback is

(a) $\frac{1}{6}$ (b) ∞ (c) 0 (d) 1

1.10 The final value theorem is used to find the

(a) steady state value of the system output

(b) initial value of the system output

(c) transient behaviour of the system output

(d) none of these

1.11 For a second order system, damping ratio, (ξ) is $0 < \xi < 1$, then the roots of the characteristic polynomial are

(a) real but not equal
(b) real and equal
(c) complex conjugates
(d) imaginary

1.12 The transfer function of a linear system is the

(a) ratio of the output, $v_0(t)$, and input, $v_i(t)$
(b) ratio of the derivatives of the output and the input
(c) ratio of the Laplace transform of the output and that of the input with all initial conditions zeros
(d) none of these

1.13 e^{At} can be expanded as

(a) $\sum_{k=0}^{\infty} \frac{A^k t^k}{(k+1)!}$
(b) $\sum_{k=0}^{\infty} \frac{A^k t^k}{k!}$
(c) $\sum_{k=0}^{\infty} \frac{A^k t^{k+1}}{(k+1)!}$
(d) $\sum_{k=0}^{\infty} \frac{A^k t^k}{k!}$

1.14 Non-minimum phase transfer function is defined as the transfer function

(a) which has zeros in the right half S-plane
(b) which has zeros only in the left-half S-plane
(c) which has poles in the right half S-plane
(d) which has poles in the left-half S-plane

1.15 The solution of $X = A(t)X(t)$, is

(a) e^{At}, X_0
(b) $e^{\int_{t_0}^{t} A(\tau)d\tau}.X_0$
(c) $\left[I + \int_{t_0}^{t} A(\tau)d\tau\right].X_0$
(d) None of these

1.16 Let h(t) be the impulse response of al linear time invariant system. Then the response of the system for any input u(t) is

(a) $\int_0^t h(\tau)u(t-\tau)d\tau$
(b) $\frac{d}{dt}\int_0^t h(\tau)u(t-\tau)d\tau$
(c) $\left[\int_0^t h(\tau)u(t-\tau)d\tau\right]$
(d) $\int_0^t h^2(\tau)u(t-\tau)d\tau$

1.17 The probability that an electron in a metal occupies the Fermi-level at any temperature (> 0 K)

(a) 0 (b) 1 (c) 0.5 (d) 1.0

1.18 The drift velocity of electrons, in silicon

(a) is proportional to the electric field for all values of electric field
(b) is independent of the electric field
(c) increases at low values of electric field and decreases at high values of electric field exhibiting negative differential resistance.
(d) increases linearly with electric field at low values of electric field and gradually saturates at higher values of electric field.

1.19. The diffusion potential across a P-N junction

(a) decreases with increasing doping concentration
(b) increases with decreasing band gap
(c) does not depend on doping concentration
(d) increases with increase in doping concentrations

1.20. The breakdown voltage of a transistor with its base open is BV_{CEO} and that with emitter open is BV_{CBO}, then

(a) $BV_{CEO} = BV_{CBO}$ (b) $BV_{CEO} > BV_{CBO}$ (c) $BV_{CEO} < BV_{CBO}$
(d) BV_{CEO} is not related to BV_{CBO}

1.21. In a P type silicon sample, the hole concentration is $2.25 \times 10^{15} / cm^3$. If the intrinsic carrier concentration is $1.5 \times 10^{10} / cm^3$, the electron concentration is

(a) zero (b) $10^{10} / cm^3$ (c) $10^5 / cm^3$
(d) $1.5 \times 10^{25} / cm^3$

1.22. A zener diode works on the principle of

(a) tunneling of charge carriers across the junction
(b) thermionic emission
(c) diffusion of charge carriers across the junction
(d) hopping of charge carriers across the junction

1.23. A BJT is said to be operating in the saturation region if

(a) both the junctions are reverse biased
(b) base emitter junction is reverse biased and base-collector junction is forward biased.

(c) base emitter junction is forward biased and base-collector junction reverse biased
(d) both the junctions are forward biased

1.24. The depletion capacitance, C_J, of an abrupt P-N junction with constant doping on either side varies with reverse bias, V_R, as

(a) $C_J \propto V_R$ (b) $C_J \propto V_R^{-1}$ (c) $C_J \propto V_R^{\frac{-1}{2}}$ (d) $C_J \propto V_R^{\frac{-1}{3}}$

1.25 A change in the value of the emitter resistance, R_e, in a difference amplifier

(a) affects the difference mode gain A_d
(b) affects the common mode gain A_c
(c) affects both A_d and A_c
(d) does not affect either A_d and A_c

1.26 The Ebers-Moll model is applicable to

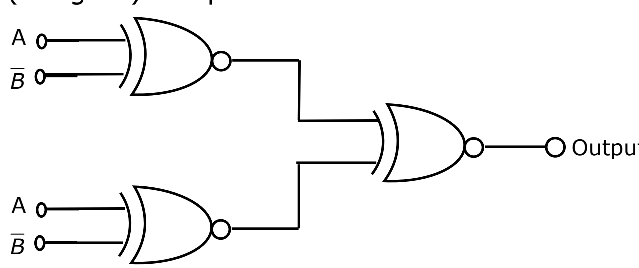
(a) bipolar junction transistors (b) NMOS transistors
(c) unipolar junction transistors (d) junction field-effect transistors

1.27 To obtain very high input and output impedances in a feedback amplifier, the topolomostly used is

(a) voltage series (b) current series
(c) voltage shunt (d) current shunt

1.28 The output of the circuit shown (in figure) is equal to

(a) 0
(b) 1
(c) $\overline{A}B + A\overline{B}$
(d) $\overline{(A * B)} * \overline{(A * B)}$



1.29 The minimum number of NAND gates required to implement the Boolean function $A + A\overline{B} + A\overline{B}C$, is equal to

(a) zero (b) 1 (c) 4 (d) 7

1.30 A switch-tail ring counter is made by suing a single D flip-flop. The resulting circuit is a

(a) SR flip-flop (b) JK flip-flop (c) D flip-flop (d) T flip-flop

1.31 When a CPU is interrupted, it
(a) stops execution of instructions
(b) acknowledges interrupt and branches of subroutine
(c) acknowledges interrupt and continues
(d) acknowledges interrupt and waits for the next instruction from the interrupting device.

1.32 The minimum number of MOS transistors required to make a dynamic RAM cell is
(a) 1 (b) 2 (c) 3 (d) 4

1.33 An R-S latch is a
(a) combinatorial circuit (b) synchronous sequential circuit
(c) one bit memory element (d) one clock delay element

1.34 A 'DMA' transfer implies
(a) direct transfer of data between memory and accumulator
(b) direct transfer of data between memory and I/O devices without the use of μP
(c) transfer of data exclusively within μP registers
(d) A fast transfer of data between μP and I/O devices

1.35 An 'Assembler' for a microprocessor is used for
(a) assembly of processors in a production line
(b) creation of new programmes using different modules
(c) translation of a programme from assembly language to machine language
(d) translation of a higher level language into English text

1.36 The image (second) channel selectivity of a super beterodync communication receiver is determined by
(a) antenna and pre-selector (b) the pre-selector and RF amplifier
(c) the pre-selector and IF amplifier (d) the RF and IF amplifier

1.37 For a narrow band noise with Gaussian Gradrature components, the probability density function of its envelope will be
(a) uniform (b) Gaussian (c) exponential (d) Rayleigh

1.38 If the number of bits per sample in a PCM system is increased from improvement in signal to quantization noise ratio will be
(a) 3 dB (b) 6 dB (c) 2n dB (d) 0 dB

1.39 A PLL can be used to demodulate

(a) PAM signals (b) PCM signals
(c) FM signals (d) DSB-SC signals

1.40 A PAM signal can be detected by using

(a) an ADC (b) an integrator
(c) a band pass filter (d) a high pass filter

1.41 A 1.0 kHz signal is flat-top sampled at the rate of 1800 samples sec and the samples are applied to an ideal rectangular LPF with cut-off frequency of 1100 Hz, then the output of the filter contains.

(a) only 800 Hz component (b) 800 Hz and 900 Hz components
(c) 800 Hz and 1000 Hz components
(d) 800 Hz, 900 and 1000 Hz components

1.42 The signal to quantization noise ratio in an n-bit PCM system

(a) depends upon the sampling frequency employed
(b) is independent of the value of 'n'
(c) increases with increasing value of 'n'
(d) decreases with the increasing value of 'n'

1.43 The electric field strength at a distance point, P, due to a point charge, +q, located on the origin, is 100μ V/m. If the point charge is now enclosed by a perfectly conducting metal sheet sphere whose centre is at the origin, then the electric field strength at the point P outside the sphere becomes.

(a) zero (b) 100 μ V/m (c) -100 μ V/m (d) 50 μ V/m

1.44 In the infinite plane, y = 6m, there exists a uniform surface charge density of ($1600\ \pi$) 100 C/m^2. The associated electric field strength is:

(a) 30 i V/m (b) 30 j V/m (c) 30 k V/m (d) 60 i V/m

1.45 The intrinsic impedance of a lossy dielectric medium is given by

(a) $\frac{j\omega\mu}{\sigma}$ (b) $\frac{j\omega\varepsilon}{\mu}$ (c) $\sqrt{\frac{j\omega\mu}{\sigma + j\omega\varepsilon}}$ (d) $\sqrt{\frac{\mu}{\varepsilon}}$

1.46 An antenna, when radiating, has a highly directional radiation pattern, when the antenna is receiving, its radiation pattern

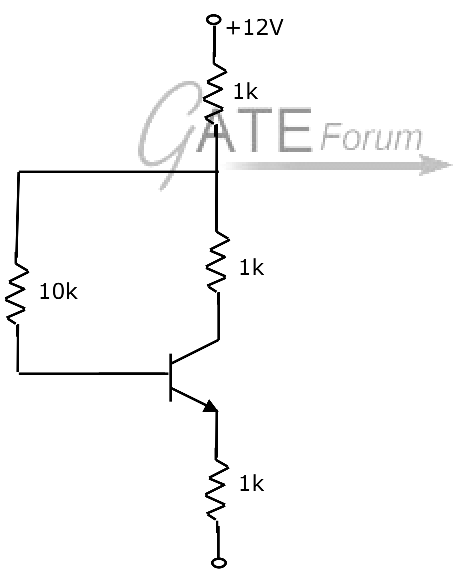
(a) is more directive (b) is less directive
(c) is the same (d) exhibits no directivity at all

1.47 Copper behaves as a
(a) conductor always
(b) conductor or dielectric depending on the applied electric field strength
(c) conductor or dielectric depending on the frequency
(d) conductor or dielectric depending on the electric current density

2. In each of the following questions, (2.1 – 2.10), fill in the blanks approximately.

2.1 A series R-L-C circuit has a Q of 100 and an impedance of $(100 + j0)\,\Omega$ at its resonant angular frequency of 10^7 radian/sec. The values of R and L are: R = _______ ohms, L = ________ ohms.

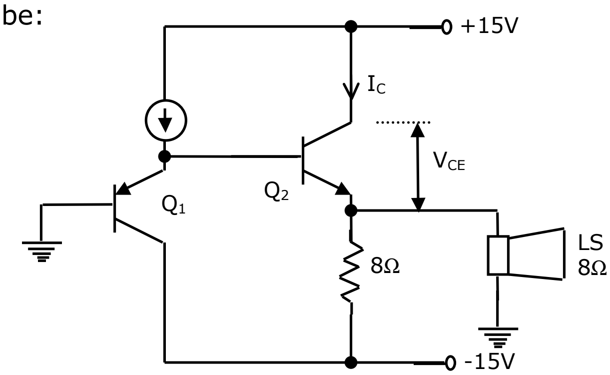
2.2. A transistor having α = 0.99 and $V_{BE} = 0.7V$, is used in the circuit shown (figure). The value of the collector current will be ______



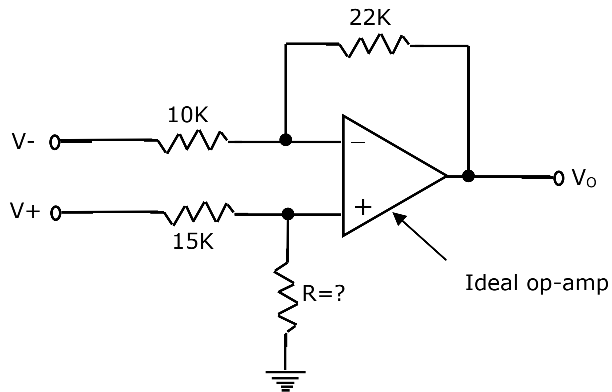
2.3. The circuit shown (in figure) supplies power to an 8Ω speaker, LS. The values of I_C and V_{CE} for this circuit will be:

I_C = ______________

and V_{CE} = ______________



2.4. In the given circuit (figure), if the voltage V_- and V_+ are to be amplified by the same amplification factor, the value of R should be



2.5. An npn transistor under forward active mode of operation is biased at I_C =1mA, and has a total emitter-base capacitance C_K of 12pF, and the base transit time τ_F of 260 psec. Under this condition, the depletion capacitance of the emitter-base junction is _________. [use $V_T = 26mV$]

2.6. An RC coupled amplifier is assumed to have a single-pole low frequency transfer function. The maximum lower cut-off frequency allowed for the amplifier to pass 50 Hz square wave with no more than 10% tilt is __________.

2.7. An Op-amp is used as a zero-crossing detector. If the maximum output available from the Op-amp is ±12V p-p, and the slew rate of the Op-amp is 13 V/μsec, then the maximum frequency of the input signal that can be applied without causing a reduction in the p-p output is ____________.

2.8. A power amplifiers delivers 50W output at 50% efficiency. The ambient temperature is 25°C. If the maximum allowable junction temperature is 150°C, then the maximum thermal resistance ϕ_{jc} than can be tolerated is ________.

2.9. An amplifier has an open-loop gain of 100, and its lower and upper cut off frequency of 100 Hz and 100 kHz, respectively. A feedback network with a feedback factor of 0.99 is connected to the amplifier. The new lower and upper cut off frequencies area at _________ and __________.

2.10. An n-channel JFET has $I_{DSS} = 1mA$ and $V_P = -5V$. Its maximum transconductance is _____________.

3. In each of the following questions (3.1 – 3.9), match each of the items, A, B, and C with an appropriate item from 1, 2, 3, 4 and 5.

Note: Marks will be given only if ALL the three items, A, B and C are matche correctly.

3.1

(A) Fourier transform of a Gaussian function	(1) Gaussian function
(B) Convolution of a rectangular pulse with itself	(2) Rectangular pulse
(C) Current through an inductor for a step input voltage	(3) Triangular pulse
	(4) Ramp function
	(5) Zero

3.2 In a bipolar junction transistor if

(A) the current gain increases	(1) the base doping is increased and the base width is reduced
(B) the collector break-down voltage increases	(2) the base doping is reduced and the base width is increased
(C) the cutoff frequency increases	(3) the base doping and the base width are reduced
	(4) the emitter area is increased and the collector area is reduced
	(5) the base doping and the base width are increased

3.3. In a JFET If

(A) the pinch off voltage decreases	(1) the channel doping is reduced
(B) the transconductance increases	(2) the channel length is increased
(C) the transit time of the carriers in the channel is reduced	(3) the conductivity of the channel increased
	(4) the channel length is reduced
	(5) the Gate area is reduced

3.4.

In an extrinsic semiconductor If

(A) the resistivity decreases	(1) the doping concentration is low
(B) the temperature coefficient of resistivity is negative	(2) the length of the semiconductor is reduced
(C) the photo conductivity is low	(3) the band gap is high

(4) the area of cross-section of the semiconductor is increased

(5) the doping concentration is incrased

3.5. For a TTL gate, match the following

(A) V_{OH} (min)	(1) 2.4 volts
(B) V_{IH} (min)	(2) 1.5 volts
(C) V_{OL} (max)	(3) 0.4 volts
(D)	(4) 2.0 volts
	(5) 0.8 volts

3.6. For an ADC, match the following

(A) Flash converter	(1) requires a conversion time of the order of a few seconds
(B) Dual slope converter	(2) requires a digital to analog converter
(C)Successive approximation converter	(3) minimizes the effect of power supply interference
	(4) requires a very complex hardware
	(5) is a tracking A/D converters

3.7.

(A) Common collector amplifier	(1) Provides voltage gain but no current gain
(B) Common emitter amplifier	(2) Provides current gain but no voltage gain
(C) Common base amplifier	(3) Provides neither voltage nor power gain
(D)	(4) Provides neither current nor power gain
	(5) Provides both voltage and current gain

3.8.

(A) AM system	(1) Coherent detection
(B) DSB-SC system	(2) Envelope detection
(C) PAM system	(3) Correlation detection
(D)	(4) PLL
	(5) LPF

3.9.

(A) AM system	(1) 2B (Band width of the modulating signal)
(B) SSB system	(2) 2B
(C) PCM (n bit) system	(3) Between B and 2B
	(4) 2nB
	(5) nB

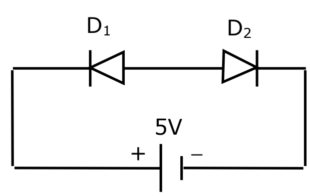
4. $V_0(s) = \dfrac{A}{s^2+1}\coth(\alpha s)$

Where α is a constant. Determine the value of α.

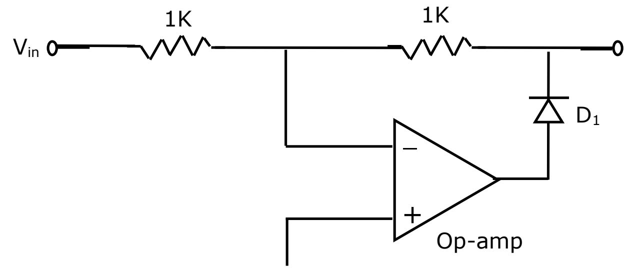
5. Obtain a state space representation in diagonal form for the following:

$$\frac{d^3y}{dt^3} + 6\frac{d^2y}{dt^2} + 11\frac{dy}{dt} + 6y = 6u(t)$$

6. Two identical silicon junction diodes, D_1 and D_2 are connected back to back as shown figure. The reverse saturation current, Is, of each diode is 10^{-8} Amps and the break down voltage, V_{Br}, is 50V. Evaluate the voltage V_{D1} and V_{D2} dropped across the diode D_1 and D_2 assuming kT/q to be 25mV.



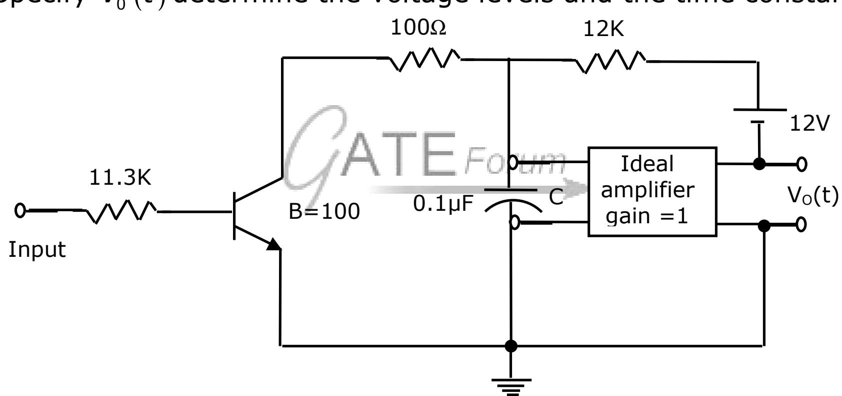
7. Sketch the output as a function of the input voltage (for negative values) for circuit shown in figure. Show all the OP-AMP, and forward drop of the diode $D_1 = 0$.



8. The waveform input to the sweep generator circuit shown in figure, is a square wave of period 2m sec and an amplitude varying between 0 and 12 volts.

(a) Draw the waveform $V_0(t)$, in relation to the input

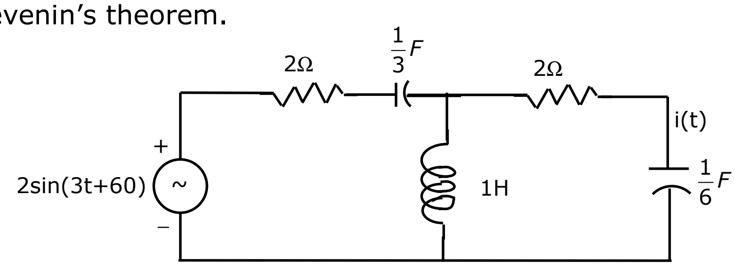
(b) Specify $V_0(t)$ determine the voltage levels and the time constants involved.



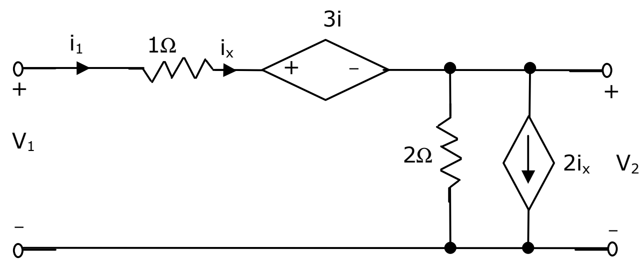
SECTION – B

(Attempt any TEN questions from this section. Each question carries 5 marks)

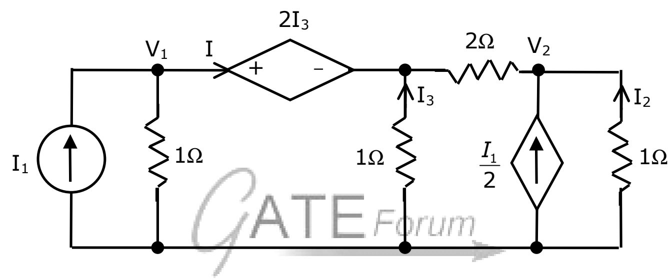
9. Determine the current, $i(t)$, in the circuit given below, (in figure below), using the Thevenin's theorem.



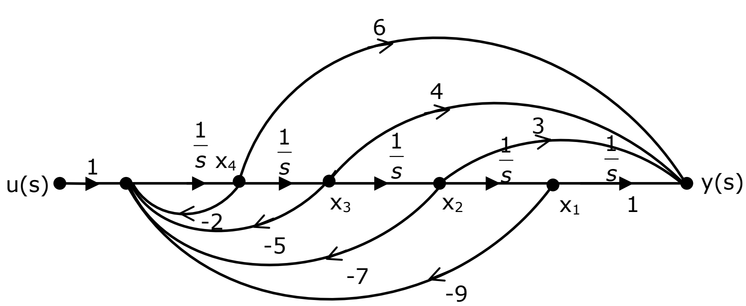
10. For the 2-port network shown in figure, determine the h-parameters. using these parameters, calculate the output (port '2') voltage, v_2, when the output port is terminated in a 3Ω resistance and a 1V (DC) is applied at the input port $(V_1 = 1V)$.



11. Find the current transfer-ratio, $\frac{I_2}{I_1}$, for the network shown below (figure). Also, mark all branch currents



12. From the signal flow graph shown in figure, obtain the state space model with x_1, x_2, x_3 and x_4 as state variables and write the transfer function directly from the state space model.



13. Solve the following differential equation by covering it into state variable form.

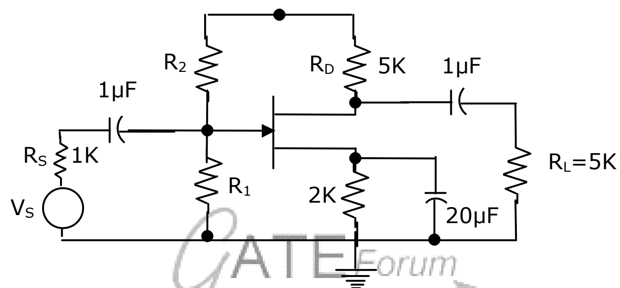
$$\frac{d^2y}{dt^2} + \frac{dy}{dt} - 2y = u(t)e^{-1}$$

Where $y(0) = 0, u(t) =$ unit step input.

14. Calculate the capacitance of a circular MOS capacitor, of 0.5 mm dia and having a SiO_2 layer of 80 mm thickness, under strong accumulation. Assume the relative dielectric ε_r of SiO_2 to be 4, ε_0 to be $8.854 \times 10^{-14} F/cm$. Calculate the break down voltage of the capacitor if the dielectric strength of SiO_2 film is $10^7 V/cm$.

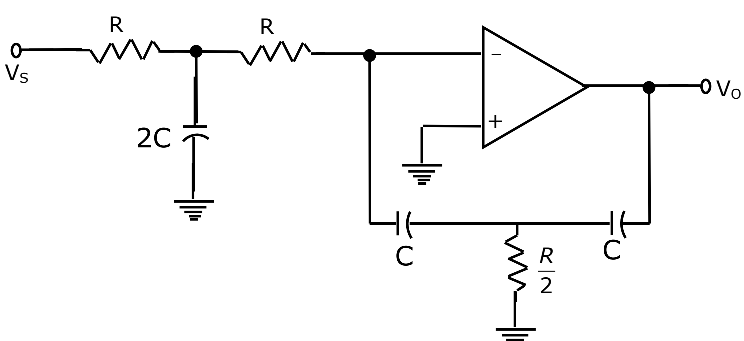
15. The Fermi level of an n-type Germanium film is 0.2 eV above the intrinsic Fermi level (towards the conduction band). The thickness of the film is 0.5 μm. calculate the sheet resistance of the film. Assume: $n_i = 10^{13} cm^{-3}, \mu n = 3500 cm^2 / V.\sec, \sec p = 1500 cm^2 / V, kT/q = 0.026V.$

16. In the JFET circuit shown in figure assume that $R_1 \parallel R_2 = 1M\Omega$ and the total stray capacitance at the output to be 20 pF. Determine the under cut-off frequency of the amplifier.

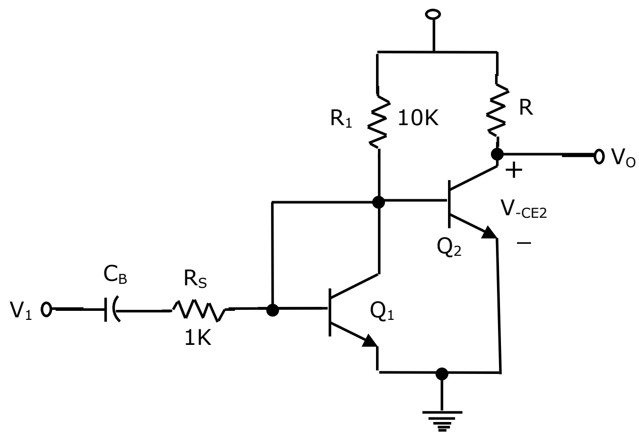


17. Show that the system shown in figure is a double integrator. In other words prove that the transfer gain is given by

$$\frac{V_0(s)}{V_s(s)} = \frac{1}{(CR_s)^2},$$ assume ideal OP-AMP.



18. In the amplifier circuit shown in figure, determine the value of R such that Q_2 is biased at $V_{CE2} = 7.5V$. Assume Q_1 and Q_2 to be identical, $V_{BE} = 0.7V$ and neglect base currents. Also, determine the small signal input impedance of Q_1 and Q_2, if both of them have $\beta = 200$. Use $V_T = 26mV$.



19. A ROM is to be used to implement the Boolean functions given below.

$F_1(A,B,C,D) = ABCD + A\ B\ C\ D$

$F_2(A,B,C,D) = (A+B)(A+B+C)$

$F_3(A,B,C,D,) = \sum 13,15 + \sum 3,5$

(a) What is the minimum size of the ROM required?

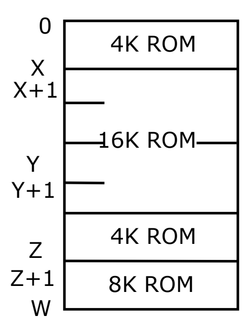
(b) Determine the data in each location of the ROM.

20. A hypothetical CPU has a parallel address bus, a parallel data bus, a $\overline{RD}$ and a $\overline{WR}$ signal. Two ROMs of size 4K words each and two RAMs of sizes 16K and 8K words, respectively, are to be connected to the CPU. The memories are to be so connected that they fill the address space of the CPU as per the memory map shown in the figure. Assuming that chip select signals are active low.

(a) What is the number of lines in the address bus of the CPU?

(b) Determine the values of address X, Y, Z and W as decimal numbers.

(c) Using a 2-4 decoder and some additional gates, draw a circuit for the decoding logic.

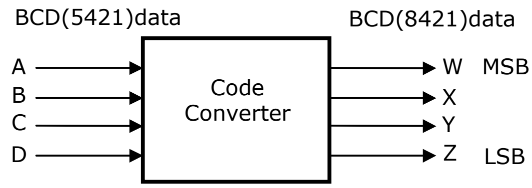


21. A 'code converter' is to be designed to convert from the BCD (5421) to the normal BCD(8421). The input BCD combinations for each digit the given below. A block diagram of the converter is shown in figure.

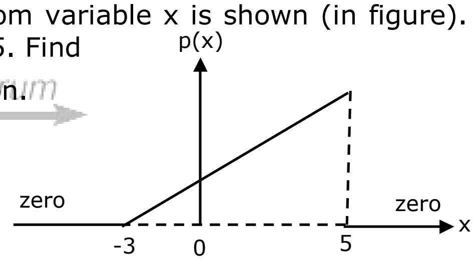
(a) Draw K-maps for outputs, W, X, Y and Z.

(b) Obtain minimized expression for the outputs W, X, Y and Z.

Decimal	BCD(5421)			
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	1	0	0	0
6	1	0	0	1
7	1	0	1	0
8	1	0	1	1
9	1	1	0	0



22. The probability density function of a random variable x is shown (in figure). The density function is zero for x < 3 and x > 5. Find
   (a) the largest value of the density function.
   (b) E(x) and
   (c) $Var[x]$.



23. The message signal input to a delta modulator is m(t) = 6 sin(2π 1000t) + 4 sin (2π 2000t) volt, with t in seconds. Determine the minimum pulse rate that will prevent the slope over load, if the step size is 0.314 volt.

24. A carrier signal of 1.0 volt amplitude and a sinusoidal modulating signal of 0.5 V, put in series, are applied to a square law modulator of characteristics,

$$i_0 = 10 + Kv_i + K'v_c^2 mA$$

Where v_i is input in volts, K = 2mA/V and $K' = 0.2mA/V^2$. Considering only the frequency components of the AM signal corresponding to the carrier frequency, find the depth of modulation in the resulting AM signal.

25. A signal $v(t) = [1 + m(t)]\cos(\omega_c t)$ is detected using a square law detector, having the characteristic $v_0 = V^2$. If the Fourier transform of $m(t)$ is constant, M_0, extending from $-f_m$ to $+f_m$, sketch the Fourier transform of $v_0(t)$ in the frequency range $-f_m < f < f_m$.

26. Three electrostatic point charges are located in the xy-plane as given below:

$$+Q \text{ at } \left(-\frac{a}{2}, 0\right) + Q \text{ at } \left(\frac{a}{2}, 0\right) \text{ and -2Q at } \left(0, a\sqrt{3}/2\right)$$

Calculate the coordinates of the point, P, on the y-axis, where the potential to these charges is zero. Also, calculate the magnitude of the electric field strength at P. At the point, P, what is the angle between the equi-potential passing through P and the y-axis?

27. Two dipoles are so feed and oriented in free space that they produce the following electromagnetic waves:

$$E_x = 10e^{j\left(\omega t - \frac{z\pi}{3}\right)} \text{ volts/metre}$$

$$E_x = j10e^{j\left(\omega t - \frac{z\pi}{3}\right)} \text{ volts/metre}$$

(a) Write down the expression for the corresponding magnetic field strength vector.

(b) Calculate the frequency of the wave

(c) Given the complete description of the polarization of the wave.

28. A rectangular hollow metal waveguide is required to be so designed to propagate a 9375 MHz signal in its TE_{10} mode that the guide wavelength equals the cut-off wavelength. Calculate the value of 'a' (breadth or the wider dimension of the waveguide). Take $b = \frac{a}{2}$. Also, calculate the cut-off frequency of the next higher order mode.