Maximum Marks: 60
Duration: Three Hours

Note: Answer all the questions. Start each part from new page.

1. (a) (i) Find the Laplace transform of
\[ \int_0^t \frac{e^{-s} - e^{-s}}{t} \, dt. \]
(ii) Find the Laplace transforms of
\[ L[e^{-s} \cos^2 t] \text{ and } L[t^2 e^t \sin 4t] \]
(iii) Find the inverse Laplace transform of
\[ L^{-1} \left[ \frac{S}{(s^2 + 4)^3} \right] \text{ using convolution theorem}. \]
(b) Solve the differential equations by Laplace transform
\( (D^2 - 2D + 2) = 1 - e^{2t}, \)
y(0) = y'(0) = 0.

OR

(b') Solve the following simultaneous differential equation by Laplace transform methods.
\[ \frac{dx}{dt} + 4 \frac{dy}{dt} - y = 0 \]
\[ \frac{dx}{dt} + 2y = e^t \text{ with condition} \]
x(0) = y(0) = 0.

2. (a) \( r = x\hat{i} + y\hat{j} + z\hat{k}, \) show that
(i) \( \text{div}(\vec{r}\hat{o}) = 3\hat{o} + \hat{r}, \text{ grad } \phi \)
(ii) \( \text{div} \left( \frac{\vec{r}}{r^2} \right) = 0 \)
(b) Find the directional derivative at \((1, 2, 1)\) on the sphere \( x^2 + y^2 + z^2 = 6 \) in the direction normal to the surface \( z = 2x^2 + y^2 = 5 \) at the same point.
(c) Prove that for any vector field \( \vec{A} \)
\[ \text{div} \text{ curl } \vec{A} = 0 \]

OR

(c') Show that the vector field given by
\[ \vec{A} = (2x \hat{i} + y^2 \hat{j}) + (2yz + x^2 )\hat{j} + (2xz + y^2 )\hat{k} \]
is irrotational. Find scalar function \( f \) such that \( \vec{A} = \text{grad } f. \)

[5+5+5]
3. (a) If \( \mathbf{A} = (3x^2 + 6y)i - 14yz j + 20xz^2 k \), evaluate \( \oint \mathbf{A} \cdot d\mathbf{r} \) from \((0, 0, 0)\) to \((1, 1, 1)\), along the straight lines from \((0, 0, 0)\) to \((1, 0, 0)\) then \((1, 1, 0)\) and then to \((1, 1, 1)\).

(b) Use divergence theorem to evaluate \( \iint_S \mathbf{F} \cdot d\mathbf{S} \), where \( \mathbf{F} = 4x^2 - 2y^2 j + z^3 k \) and \( S \) is the surface boundary the region \( x^2 + y^2 = a^2 \), \( z = 0, z = -3 \).

(c) If \( \mathbf{F} = y\mathbf{i} + (x - 2xz)\mathbf{j} - xy\mathbf{k} \), evaluate \( \iint_S \left( \nabla \times \mathbf{F} \right) \cdot d\mathbf{S} \)

Where \( S \) is the surface of the sphere \( x^2 + y^2 + z^2 = a^2 \) above the xy-plane.

OR

(c') Use Green's theorem in a plane to evaluate the integral \( \int_C \left( 2x^2 - y^2 \right) dx + \left( x^2 + y^2 \right) dy \) where \( C \) is the boundary of the surface in the xy-plane enclosed by x-axis and semi circle \( y = \sqrt{1-x^2} \).

4. (a) If 4 cards are drawn at random from a pack of 52 cards, what is the probability that one will be from each suit? What is the probability that all four will be from the same suit?

(b) The probability that a man aged 60 will live to be 70 is 0.65. What is the probability that out of 10 men, now 60, at least 7 would live to be 70?

(c) Suppose that the two-dimensional continuous random variable \((X, Y)\) has joint pdf given by

\[ f(x, y) = x^2 + \frac{xy}{3}, \quad 0 \leq x \leq 1, \quad 0 \leq y \leq 2, \]

\[ = 0, \text{ elsewhere}. \]

Compute the following:

(i) \( P\left(X > \frac{1}{2}\right) \)

(ii) \( P(Y < X) \)

(iii) \( P\left(Y < \frac{1}{2} \mid X < \frac{1}{2}\right) \)
Maximum Marks: 60

Note: Answer all the questions. While doing numerical calculations, round off your calculation to five decimal places after every intermediate step.

Q. 1. (5 marks)
(a) Show that \( \varphi(x, y) = e^x(x \cos y - y \sin y) \) is a harmonic function and find a conjugate function \( \psi(x, y) \).

(b) Find the real and imaginary parts of the function \( f(z) = \cos 2z \) and show that they satisfy the Cauchy-Riemann equations for all \( z \) in the plane. Also show that \( \frac{df}{dz} = -2 \sin 2z \).

(c) Show that the polar form of the Cauchy-Riemann equations are \( \frac{\partial u}{\partial \theta} = \frac{\partial v}{\partial r} \), \( \frac{\partial u}{\partial r} = -\frac{\partial v}{\partial \theta} \).

(c') Use the Cauchy integral formula and evaluate
\[
\int_C \frac{4z}{(z-1)(z+2)^2} \, dz
\]
where \( C \) is the circle \( |z-1| = \sqrt{6} \).

OR

Q. 2. (7 marks)
(a) Expand the function \( f(z) = e^z \sin \left( \frac{1}{z^2} \right) \) about (i) \( z = 0 \) and (ii) \( z = 1 \) and show that it has a Taylor series representation about \( z = 0 \) and a Laurent series expansion about \( z = 1 \). Determine the type of singularity of the point \( z = 1 \).

(b) Using Residue theorem, evaluate the contour integral
\[
\int_C \frac{dz}{z^3(z^2 + 2z + 2)}
\]
where \( C \) is the circle \( |z| = 3 \).

OR

(b') Using a suitable contour integral, evaluate the following real integral
\[
\int_0^{2\pi} \frac{\cos 3\theta}{3 - 4 \cos \theta} \, d\theta
\]

Q. 3. (5 marks)
(a) Compute the real root of \( x \log_{10} x - 1.2 = 0 \), correct to four decimal places by Newton Raphson method. Also discuss the order of convergence.

(b) Solve the following system of linear equations by Gauss elimination method with partial pivoting.

\[
\begin{align*}
3.15x - 1.96y + 3.85z &= 12.95 \\
2.13x + 5.12y - 2.89z &= -8.61 \\
5.92x + 3.05y + 2.15z &= 6.88
\end{align*}
\]
OR

(b') Solve the following system of linear equations by Gauss Seidal method, tabulating the result up to three iterations.

\[
\begin{align*}
    x + y + z &= 4.280 \\
    0.2x - 0.1y - 0.5z &= -1.978 \\
    4.1x + 0.3y + 0.12z &= 1.686
\end{align*}
\]

(c) Fit a polynomial of third degree using Lagrange's interpolation for the data given below.

\[
\begin{array}{|c|c|c|c|}
\hline
x & 0 & 1 & 3 & 4 \\
\hline
y & 443 & 384 & 397 & 467 \\
\hline
\end{array}
\]

Q. 4.

(a) From the following table of values of \(x\) and \(y\), find \(\frac{dy}{dx}\) at 1.05 and \(\frac{d^2y}{dx^2}\) at \(x = 1.25\).

\[
\begin{array}{|c|c|c|c|c|c|}
\hline
x & 1.00 & 1.05 & 1.10 & 1.15 & 1.20 & 1.25 & 1.30 \\
\hline
y & 1.0000 & 1.0247 & 1.0488 & 1.0723 & 1.0954 & 1.1180 & 1.1401 \\
\hline
\end{array}
\]

OR

(a') Given that \(y' = x^2y'\), \(y(1) = 1\), apply Taylor series method to approximate the values of \(y(1.1)\), \(y(1.2)\) and \(y(1.3)\) correct to four decimal places using first three terms of the Taylor series expansion and \(h = 0.1\).

(b) (i) Evaluate \(\frac{\int_1^2 2x \, dx}{11x^4}\) using Gaussian 2-point and 3-point quadrature formulas and compare with the exact solution.

(ii) Solve the boundary value problem \(\frac{dy}{dx} - y = 0\) with \(y(0) = 0\) and \(y(2) = 3.6268\) by finite difference method taking \(h = 0.5\).

---------------- END ----------------
2014-2015
B.TECH AUTUMN (III SEMESTER) EXAMINATION
(ELECTRONICS ENGINEERING)
EL-211 N
ELECTRONIC DEVICES
CREDITS: 04

Maximum Marks: 60
Duration: Three Hours

Instructions:
1. Attempt all questions
2. Make appropriate assumptions if required
3. Symbols and abbreviations have their usual meanings.

Qs

Marks

Values of some constants: Energy gap for Si = 1.12 eV; Thermal voltage (kT/q = 25 mV at room Temp.); Permittivity of free space (ε₀ = 8.85 x 10⁻¹² F/m); Permittivity of silicon (εᵣ = 12. ε₀); Permittivity of oxide (εᵅx = 3.9 ε₀); μ_p = 400 cm²/Vs; μ_n = 800 cm²/Vs; nᵣ = 1 x 10¹⁰ cm⁻³; Nₚ = 1.04 x 10¹⁶ cm⁻³; Nᵣ = 2.8 x 10¹⁹ cm⁻³

1(a) Define the mobility. Explain why the mobility in a semiconductor depends on the doping density. How mobility is related with diffusion constant?

1(b) An abrupt silicon pn junction at zero bias has dopant concentrations with N_D = 5 x 10¹⁵ cm⁻³, N_A = 5 x 10¹⁷ cm⁻³. Calculate the Fermi level on each side of the junction with respect to intrinsic Fermi level. Sketch the equilibrium energy band diagram for the junction and determine the built-in potential for the junction. Also calculate the peak electric field for this junction.

1(c) Determine output waveform for the network of Figure 1 for the input indicated. Explain all steps.

Figure 1. Applied signal and network for problem 1(c)

1*(a) Define drift current and obtain an expression for conductivity? A silicon sample is uniformly doped with 2 x 10¹⁵ boron atoms/cm². If all the dopants are fully ionized. Determine conductivity of material.
1'(b) What is Hall Effect? How mobility can be determined using Hall effect? In a p-
type semiconductor doping density is $10^{18} \text{ cm}^{-3}$ and $\mu_p = 400 \text{ cm}^2/\text{V s}$. If a
magnetic field $(B)$ of $5 \times 10^{-4} \text{ Weber/cm}^2$ is applied in +x direction, and an
electric field of $2000 \text{ V/cm}$ is applied in the +y direction. Determine value of the
electric field caused in +z direction due to Hall effect.

1'(c) Consider an abrupt p-n diode with $N_a = 10^{18} \text{ cm}^{-3}$ and $N_d = 10^{16} \text{ cm}^{-3}$. Calculate
the junction capacitance at zero bias. The diode area equals $10^{-4} \text{ cm}^2$.

2(a) Assume that a silicon transistor is operating at room temperature with $\beta = 100$,
$V_{BE} = 0.6 \text{ V}$, $V_{CE} = 25 \text{ V}$, and $R_C = 6 \text{ K}$ is used as shown in Figure 2. It is desired
to establish a Q point at $V_{CE} = 12 \text{ V}$, $I_C = 1.5 \text{ mA}$, Find $R_{CB}$, $R_1$, $R_2$ and $g_m$.

![Figure 2](image2.png)

2(b) What is the need of biasing in BJT? Describe different biasing scheme used in discrete
BJT circuits.

2(c) The BJT in circuit Figure 3 has $\beta = 100$. Find the dc collector current and dc voltage at
collector. Replacing the transistor by its T model, draw the small signal equivalent circuit
of the amplifier. Determine the voltage gain.

![Figure 3](image3.png)

OR

2'(c) Determine the small signal resistance (between collector and emitter) of a BJT
connected in CE configuration (operating in active region) if its collector is
connected to its base.
3(a) Explain the working of a depletion type MOSFET. How it can be used as an enhancement type MOSFET? What do you mean by voltage controlled resistor?

3(b) For a CS MOSFET amplifier shown in Figure 4, determine its small signal voltage gain, its input resistance and largest allowable input signal. The NMOS transistor have

\[ V_t = 1.5V \quad \text{and} \quad K_n \left( \frac{W}{L} \right) = 0.25 \text{mA/V}^2. \] Assume \( V_A = 50V \).

\[ R_D = 10 \text{ k} \Omega \]

\[ R_C = 10 \text{ M} \Omega \]

\[ R_s = 10 \text{ k} \Omega \]

Figure 4.

OR

3(b) The MOSFET shown in Figure 5 has \( V_t = 1.0V \) and \( K_n \left( \frac{W}{L} \right) = 0.8 \text{mA/V}^2. \) Assume \( V_A = 40V \)

Find the values of \( R_S \) and \( R_D \) so that \( I_D = 0.1 \text{ mA} \), the largest possible value of \( R_D \) is used while maximum signal swing at the drain of \( \pm 1 \text{ V} \) is possible, and the input resistance at gate is \( 10 \text{ M} \Omega \). Find values of \( g_m \) and \( r_e \) at the bias point. If \( Z \) terminal is grounded, terminal \( X \) is connected to a signal source having a resistance of \( 1 \text{ M} \Omega \), and terminal \( Y \) is connected to a load resistance of \( 40 \text{ k} \Omega \). Find the voltage gain from signal source to load. If terminal \( Y \) is grounded, find the voltage gain from \( X \) to \( Z \) with \( Z \) open circuited. What is the output resistance in this case?

Figure 5.

\( V_A = 40V \)
4(a) What is feedback? What are the effects of negative feedback on amplifier characteristics? Show that the Gain-Bandwidth product of the amplifier remains constant with and without feedback.

4(b) For the oscillator shown in Figure 6, derive the expression for the condition of oscillation as well as frequency of oscillation.

![Figure 6](image)

4(c) Suppose that the OP-AMP shown in Figure 7 has infinite input resistance and zero output resistance. Find an expression for the feedback factor. If the non-inverting amplifier shown in Figure 3 has open loop voltage gain $A = 10000$, find $R_f/R_g$ to obtain a close loop voltage gain of 10. What is the amount of feedback in decibels? If source voltage is 1V, find output voltage, feedback voltage, and input voltage. If $A$ decreases by 20%, what is the corresponding decrease in close loop voltage gain?

![Figure 7](image)
Q.No. 1(a) Find the trigonometric Fourier series for the waveform shown in Figure 1.

![Figure 1](image1)

Q.No. 1(b) Determine the resonant frequency for the circuit shown in Figure 2.

![Figure 2](image2)

Q.No. 1(c) For the network shown in Figure 3, find the Norton’s equivalent at

(a) Terminals a & b
(b) Terminals b & c

Contd...
1'(a) Determine the voltage across \((1/3)\Omega\) resistor in Figure 4 using Thevenin's theorem. [05]

1'(b) Find the mesh currents for the network shown in Figure 5. [05]

1'(c) With the help of circuit analysis determine the impedance and phase angle of a series RLC Circuit. Also draw the corresponding phasor diagram. [05]
2(a) Prove the statement that "In a linear graph every cut set has an even number of branches in common with every loop."

2(b) Write the matrix loop equations for the network shown in Figure 6 and determine the loop currents.

2(c) With the help of a graph, express the relation between branch current and loop current.

3(a) Derive the equivalent circuit of a general two port network using its z-parameters and one controlled source model. Obtain its special case when the network is reciprocal.

3(b) Obtain the parameters of a two port formed by series connection of three, two-port networks A, B and C in terms of the parameters of the individual networks.

OR

3'(a) Derive the relationships giving the h-parameters of a two port network in terms of its z-parameters.

3'(b) Find the resultant parameters for two 2-port networks connected in cascade.

4(a) Write the state equations of the circuit shown in Figure 7.
4(b) Briefly define the following terms:
   (i) Capacitor only loop
   (ii) Inductor only cutset
   (iii) Normal tree
   (iv) Order of complexity

4(c) With the help of graph theory, write the state equations for the circuit shown in Figure 8.
2014-15
B.TECH. (AUTUMN SEMESTER) EXAMINATION
ELECTRONICS ENGINEERING
ELECTRONIC INSTRUMENTATION
EL-222

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No. Question M.M.
1.(a) Define accuracy and precision. Explain why a precise instrument may not necessarily be accurate? [05]
1.(b) Explain with suitable circuit diagrams, the working of an Analog Electronic multimeter. [07]
2.(a) Explain the construction and principle of operation of an electrodynamometer type wattmeter. [06]
2.(b) Explain the measurement of frequency using block diagram. [06]
3. State the sources of errors in A.C. bridges.
A 1 kHz bridge has the following constants:
arm AB: \( R = 1 \, \text{k}\Omega \) in parallel with \( C = 0.5 \mu\text{F} \);
arm BC: \( R = 1 \, \text{k}\Omega \) in series with \( C = 0.5 \mu\text{F} \);
arm CD: \( L = 30 \text{mH} \) in series with \( R = 200 \Omega \).
Find the constants of arm DA to balance the bridge. Express the result as a pure \( R \) in series with a pure \( C \) or \( L \). [12]

OR

3'.(a) Explain any one method for the measurement of \( Q \) of a coil. [06]
3'.(b) Compute the value of self-capacitance and inductance of a coil when the following measurements are made. At frequency 2 MHz, the tuning capacitor is set at 450 Pf. When the frequency is measured to 5 MHz, the tuning capacitor is tuned at 60 pF. [06]
4. (a) What are the common applications of CROs? Explain them briefly.

4. (b) Name the special purpose CROs? Explain their applications briefly.

5. (a) What is strain gauge? Explain the measurement of strain using it. How temperature compensation is done in such strain gauges?

5. (b) A strain gauge is bonded to a beam 0.1m long and has a cross-sectional area 4 cm². Young's modulus for steel is \(207 \times 10^9\) N/m². The strain gauge has an unstrained resistance of 240Ω and a gauge-factor of 2.2. When a load is applied the resistance of gauge changes by 0.013Ω. Calculate the change in length of the steel beam and the amount of force applied to the beam.

OR

5'. (a) Describe with neat sketches any two types of transducers for the measurement of pressure.

5'. (b) A pressure measuring instrument uses a capacitive transducer having a spacing 4 mm between the diaphragms. A pressure of 600 KN/m² produces an average deflection of 0.3 mm of the diaphragms. The transducer which has a capacitance of 300 pF before application of pressure and is connected in an oscillator circuit having a frequency of 100 kHz. Determine the change in frequency of the oscillator after the pressure is applied.
1(a) For any two of the following input-output relationship, determine if systems are linear, time invariant, causal and/or memoryless:

(i) \( \frac{dy}{dt} + 4ty(t) = 2x(t) \)

(ii) \( y(t) = \sin(x(t)) \)

(iii) \( y[n] = x[2n] \)

(iv) \( y(t) = \int_{-\infty}^{2t} x(\tau)d\tau \)

1(b) Let \( x(t) \) and \( y(t) \) be periodic signals with fundamental periods \( T_1 \) and \( T_2 \), respectively. Under what conditions is the sum \( x(t) + y(t) \) periodic, and what is the fundamental period of this signal, if it is periodic?

OR

1'(b) Consider a discrete-time signal \( x[n] = n^n \) with \( a = -e^{i} \), and a continuous-time signal \( y(t) = e^{at} \). Find a complex number \( j \) such that \( y(t) \), when evaluated at \( t \) equal to an integer \( n \), is described by \((-e^{i})^n\).

1(c) Consider a periodic signal \( x_p(t) \) defined as \( x_p(t) = \sum_{n=-\infty}^{\infty} x(t-n) \), where \( x(t) \) is an aperiodic signal defined as

\[ x(t) = \cos(t), \quad -\frac{\pi}{2} \leq t \leq \frac{\pi}{2} \]

Represent \( x_p(t) \) in terms of complex exponential Fourier series and plot its spectrum.
1(d) A linear time-invariant system has impulse response \( h(t) = 2e^{-at}u(t) \). Use convolution to find the response \( y(t) \) for input \( x(t) = u(t) - u(t - 4) \).

OR

1(d) Compute and plot the discrete-time convolution \( y[n] = x[n]h[n] \), where
\[
x[n] = \left(\frac{1}{2}\right)^n u[-n-1] \quad \text{and} \quad h[n] = u[n-1]
\]

2(a) Find the Fourier transform of \( x(t) = e^{-at} \). Use this result and appropriate properties to find Fourier transform of \( g(t) = te^{-at} \).

2(b) The signal \( g(t) = 10 \cos(60\pi t) \cos^2(160\pi t) \) is sampled at the rate of 400 samples per second. Determine the spectrum of resulting sampled signal. What is the Nyquist rate for \( g(t) \)?

2(c) Determine Z-transform of sequence \( x[n] = (-1)^nu[n] \). Also indicate the region of convergence.

OR

2'(a) Fourier transform \( G(f) \) of a signal \( g(t) \) is defined by
\[
G(f) = \begin{cases} 
1, & f > 0 \\
\frac{1}{2}, & f = 0 \\
0, & f < 0 
\end{cases}
\]

Determine \( g(t) \).

2'(b) Consider a continuous-time LTI system for which the input \( x(t) \) and output \( y(t) \) are related by differential equation
\[
\frac{d^2y(t)}{dt^2} + \frac{dy(t)}{dt} - 2y(t) = x(t)
\]
Let \( X(s) \) and \( Y(s) \) denote Laplace transforms of \( x(t) \) and \( y(t) \), respectively. Find the transfer function \( H(s) \) of the system and draw pole-zero diagram of \( H(s) \). Determine impulse response of the system when system is stable (i.e. ROC includes \( j\omega \) axis).

2'(c) With the help of suitable mathematical expressions, differentiate clearly between DTFT and DFT.

2'(d) Find the Hilbert transform of \( x(t) = e^{-at} \).
3(a) Consider a continuous time LTI system implemented as RLC circuit shown in Fig. 1. The voltage source $x(t)$ is considered the input to this system. The voltage $y(t)$ across the capacitor is considered the system output. How $R$, $L$, and $C$ should be related so that there is no oscillation in the step response.

![Series RLC circuit](image)

**Fig. 1**

3(b) Using block diagram reduction technique, find the transfer function $Y(s)/R(s)$ for the system shown in Fig. 2.

![Block diagram](image)

**Fig. 2**

3(c) Discuss the conditions of stability for continuous-time and discrete-time systems. With the help of a suitable diagram and mathematical justifications, explain how a negative feedback can improve the stability of the system.

4(a) A random variable $X$ has its cumulative distribution function (cdf), $F_X(x)$ defined as:

\[
\text{contd...}
\]
\[ F_X(x) = \begin{cases} 
0, & x < 0 \\
Kx^2, & 0 \leq x \leq 10 \\
100K, & x > 10 
\end{cases} \]

(i) Find the constant \( K \).

(ii) Evaluate \( P(X \leq 5) \) and \( P(5 < x \leq 7) \).

(iii) What is probability density function (pdf) of \( X \).

OR

4(a') Consider a random variable \( X \) having probability density function

\[ f_X(x) = \begin{cases} 
x, & 0 \leq x \leq 6 \\
16, & otherwise 
\end{cases} \]

Determine mean \( E[X] \) and variance \( \sigma_X^2 \).

4(b) Consider a random process \( X(t) = A \cos(2\pi f_c t + \theta) \), where the phase \( \theta \) is a uniformly distributed random variable over the range 0 to 2\( \pi \). Find and plot the autocorrelation function (ACF) and power spectral density of this random process.

4(c) In context to random variables and random processes, define the following terms:

(i) Variance of a random variable
(ii) Covariance
(iii) Power Spectral density
(iv) Cross-correlation function
(v) Ergodicity