ESE

Electronics & Telecom. Engineering

Preliminary Examination

(Previous Years Solved Papers 1999)

Volume-II

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MADE EASY PUBLICATIONS

1 Control Systems

1. Basics, Block Diagrams & Signal Flow Graphs

1.1 When a human being tries to approach an object, his brain acts as
(a) an error measuring device
(b) a controller
(c) an actuator
(d) an amplifier [ESE-1999]

2. Time Domain Analysis

2.1 The response $c(t)$ of a system is described by the differential equation

$$\frac{d^2c(t)}{dt^2} + 4\frac{dc(t)}{dt} + 5c(t) = 0$$

The system response is
(a) undamped (b) underdamped
(c) critically damped (d) oscillatory
[ESE-1999]

2.2 The system with the open-loop transfer function

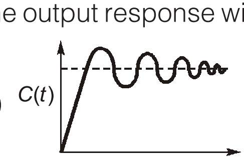
$$G(s)\,H(s) = \frac{1}{s(1+s)} \text{ is}$$

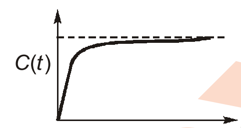
(a) type 2 and order 1
(b) type 1 and order 1
(c) type 0 and order 0
(d) type 1 and order 2
[ESE-1999]

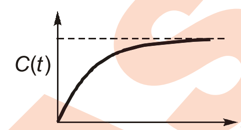
2.3 A step input is applied to a system with the transfer function

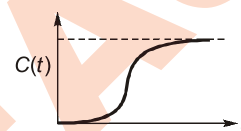
$$G(s) = \frac{e^{-s}}{1+0.5s}$$

The output response will be

(a) 

(b) 

(c) 

(d) 

[ESE-1999]

3. Routh-Hurwitz Stability Criterion

3.1 First column elements of the Routh's tabulation are 3, 5, –3/4, 1/2, 2. It means that there
(a) is one root in the left half of s-plane
(b) are two roots in the left half of s-plane
(c) are two roots in the right half of s-plane
(d) is one root in the right half of s-plane
[ESE-1999]

4. Root Locus

4.1 Consider the loop transfer function

$$G(s)\,H(s) = \frac{K(s+6)}{(s+3)(s+5)}$$

In the root-locus diagram, the centroid will be located at
(a) –4 (b) –1
(c) –2 (d) –3
[ESE-1999]

4.2 Consider the following statements:
In root-locus plot, the breakaway points

1. Need not always be on the real axis alone
2. Must lie on the root loci
3. Must lie between 0 and –1

Which of these statements are correct?

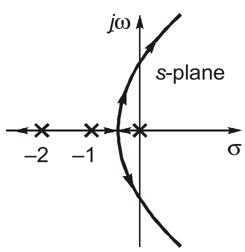
(a) 1, 2 and 3 (b) 1 and 2
(c) 1 and 3 (d) 2 and 3

[ESE-1999]

4.3 For a unity negative feedback control system, the open loop transfer function is

$$G(s) = \frac{K}{s(s+1)(s+2)}$$

The root-locus plot of the system is

(a)


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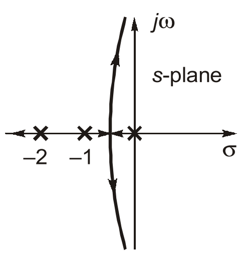

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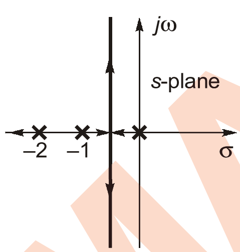

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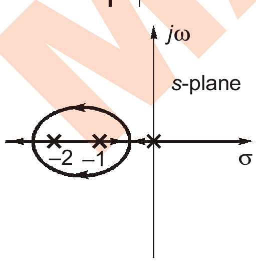


[ESE-1999]

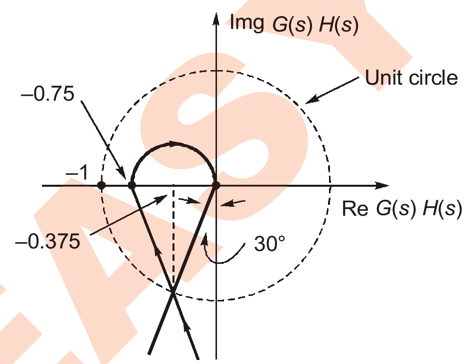
5. Frequency Domain Analysis

5.1 **Assertion (A):** The phase angle plot in Bode diagram is not affected by the variation in the gain of the system.

Reason (R): The variation in the gain of the system has no effect on the phase margin of the system.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true [ESE-1999]

5.2 A portion of the polar plot of an open-loop transfer function is shown in the given figure



The phase margin and gain margin will be respectively

(a) 30° and 0.75 (b) 60° and 0.375
(c) 60° and 0.75 (d) 60° and 1/0.75

[ESE-1999]

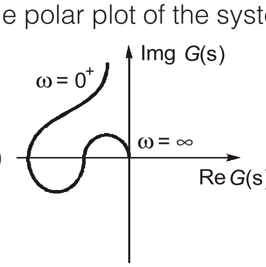
5.3 The polar plot of a transfer function passes through the critical point (–1, 0). The gain margin is

(a) 0 dB (b) –1 dB
(c) 1 dB (d) infinity [ESE-1999]

5.4 The open-loop transfer function of a unity negative feedback system is

$$G(s) = \frac{K(s+10)(s+20)}{s^3(s+100)(s+200)}$$

The polar plot of the system will be

(a)


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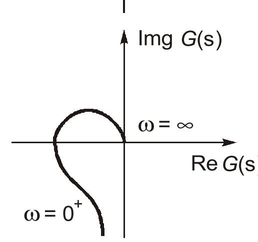
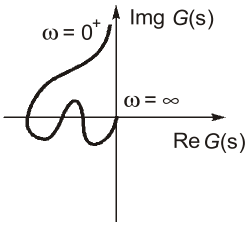
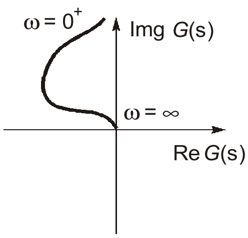


(c) 

(d) 

[ESE-1999]

6. Compensators and Controllers

6.1 If the transfer function of a phase lead compensator is $(s + a)/(s + b)$ and that of a lag compensator is $(s + p)/(s + q)$, then which one of the following sets of conditions must be satisfied?

(a) $a > b$ and $p > q$ (b) $a > b$ and $p < q$
(c) $a < b$ and $p < q$ (d) $a < b$ and $p > q$

[ESE-1999]

6.2 The compensator

$$G_C(s) = \frac{5(1+0.3s)}{1+0.1s}$$

would provide a maximum phase shift of

(a) 20° (b) 45°
(c) 30° (d) 60°

[ESE-1999]

6.3 The transfer function $G(s)$ of a PID controller is

(a) $K\left[1+\frac{1}{T_i s}+T_d s\right]$ (b) $K[1 + T_i s + T_d s]$

(c) $K\left[1+\frac{1}{T_i s}+\frac{1}{T_d s}\right]$ (d) $K\left[1+T_i s+\frac{1}{T_d s}\right]$

[ESE-1999]

6.4 The industrial controller having the best steady-state accuracy is

(a) a derivative controller
(b) an integral controller
(c) a rate feedback controller
(d) a proportional controller

[ESE-1999]

7. State Space Analysis

7.1 The state model

$$x(k+1) = \begin{bmatrix} 0 & 1 \\ -\beta & -\alpha \end{bmatrix} x(k) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(k)$$

$$y(k) = [0 \quad 1] \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix}$$

is represented in the difference equation as

(a) $c(k + 2) + \alpha c(k + 1) + \beta c(k) = u(k)$
(b) $c(k + 1) + \alpha c(k) + \beta c(k - 1) = u(k - 1)$
(c) $c(k - 2) + \alpha c(k - 1) + \beta c(k) = u(k)$
(d) $c(k - 1) + \alpha c(k) + \beta c(k + 1) = u(k + 1)$

[ESE-1999]

8. Miscellaneous

8.1 For two-phase AC servomotor, if the rotor's resistance and reactance are respectively R and X, its length and diameter are respectively L and D, then

(a) X/R and L/D are both small
(b) X/R is large but L/D is small
(c) X/R is small but L/D is large
(d) X/R and L/D are both large

[ESE-1999]

8.2 Consider the following statements relating to synchros:

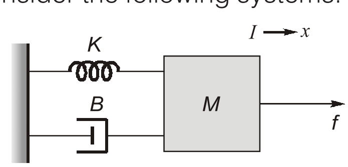
1. The rotor of the control transformer is either disc shaped
2. The rotor of the transmitter is so constructed as to have a low magnetic reluctance.
3. Transmitter and control transformer pair is used as an error detector

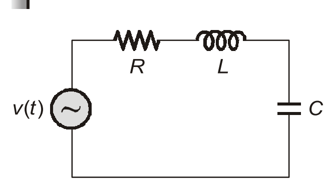
Which of these statements are correct?

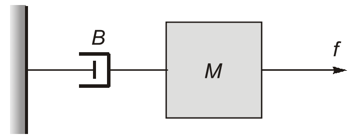
(a) 1, 2 and 3 (b) 1 and 2
(c) 2 and 3 (d) 1 and 3

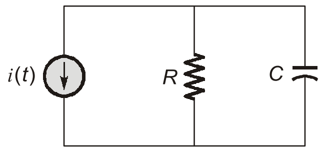
[ESE-1999]

8.3 Consider the following systems:

1. 

2. 

3. 

4. 

Which of these systems can be modelled by the differential equation,

$$a_2 \frac{d^2y(t)}{dt^2} + a_1 \frac{dy(t)}{dt} + a_0 y(t) = x(t)?$$

(a) 1 and 2 (b) 1 and 3
(c) 2 and 4 (d) 1, 2 and 4
[ESE-1999]

8.4 The radius of constant-N circle for $N = 1$ is
(a) 2 (b) $\sqrt{2}$
(c) 1 (d) $1/\sqrt{2}$ [ESE-1999]

8.5 The constant-M circle for $M = 1$ is the
(a) straight line; $x = -1/2$
(b) critical point $(-1, j0)$
(c) circle with $r = 0.33$
(d) circle with $r = 0.67$ [ESE-1999]

■■■

Answers Control Systems

1.1	(b)	2.1	(b)	2.2	(d)	2.3	(d)	3.1	(c)	4.1	(c)	4.2	(b)	4.3	(a)	5.1	(c)
5.2	(d)	5.3	(a)	5.4	(a)	6.1	(d)	6.2	(c)	6.3	(a)	6.4	(b)	7.1	(a)	8.1	(c)
8.2	(c)	8.3	(a)	8.4	(d)	8.5	(a)										

Explanations Control Systems

2. Time Domain Analysis

2.1 (b)

$$\omega_n = \sqrt{5} \text{ rad/s}$$

$$2\xi\omega_n = 4 \Rightarrow \xi = \frac{4}{2\sqrt{5}} < 1$$

$\Rightarrow$ System response is underdamped.

2.2 (d)

In the pole zero form,

$$G(s)\,H(s) = \frac{K(s+z_1)(s+z_2)\ldots}{s^n(s+p_1)(s+p_2)\ldots}$$

the type of the system is 'n' and order of the system is the highest power of s in the denominator.

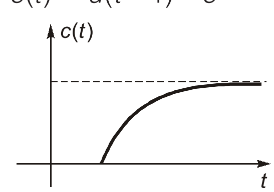
2.3 (d)

$$C(s) = G(s) \cdot R(s) = \frac{e^{-s}}{1+0.5s} \cdot \frac{1}{s}$$

$$\Rightarrow \quad C(s) = \frac{2e^{-s}}{s(s+2)}$$

$$\Rightarrow \quad C(s) = \frac{e^{-s}}{s} - \frac{e^{-s}}{s+2}$$

$$\Rightarrow \quad c(t) = u(t-1) - e^{-2(t-1)}\,u(t-1)$$



3. Routh-Hurwitz Stability Criterion

3.1 (c)

Number of roots in the right half of s-plane = number of sign changes

4. Root Locus

4.1 (c)

Centroid,

$$= \frac{\Sigma \text{real parts of poles} - \Sigma \text{real parts of zeros}}{\text{Number of poles} - \text{Number of zeros}}$$

$$= \frac{-3-5-(-6)}{2-1} = \frac{-8+6}{1} = -2$$

So, the centroid will be located at –2.

4.2 (b)

Breakaway points need not always be on the real axis alone but it must lie on the root loci. It is not necessary that break away points must lie between 0 and –1.

4.3 (a)

$$\frac{G(s)}{1+G(s)} = \frac{\frac{K}{s(s+1)(s+2)}}{1+\frac{K}{s(s+1)(s+2)}} = \frac{K}{s(s+1)(s+2)+K}$$

Characteristic equation is

$$s(s+1)(s+2) + K = 0$$

or $s^3 + 3s^2 + 2s + K = 0$

Routh array is

s^3	1	2
s^2	3	K
s	$\frac{6-K}{3}$	0
s^0	K	

For marginal stability,

$$\frac{6-K}{3} = 0 \Rightarrow K = 6$$

$$3s^2 + K = 0 \Rightarrow 3(j\omega)^2 + 6 = 0$$

$$\Rightarrow \quad -\omega^2 + 2 = 0 \Rightarrow \omega^2 = 2$$

$$\Rightarrow \quad \omega = \sqrt{2} \text{ rad/sec}$$

So, the root locus intersects with the imaginary axis at $\pm j\sqrt{2}$.

5. Frequency Domain Analysis

5.2 (d)

Phase margin = 90° – 30° = 60°
Gain margin = 1/0.75

5.3 (a)

$$\text{Gain margin} = 1/1 = 1$$
$$= 20 \log 1 \text{ dB} = 0 \text{ dB}$$

5.4 (a)

$$\angle G(j\omega)\big|_{\omega=0} = -270°$$

$$\angle G(j\omega)\big|_{\omega=\infty} = -270°$$

The polar plot intersects with the negative real axis as in making imaginary term of $G(j\omega)$ to be zero, the solution exists.

6. Compensators and Controllers

6.1 (d)

In phase lead compensator, zero is nearer to origin.
In phase lag compensator, pole is nearer to origin.

6.2 (c)

Maximum phase shift

$$\phi_m = \sin^{-1}\left(\frac{1-\alpha}{1+\alpha}\right) = \sin^{-1}\left(\frac{1-\frac{1}{3}}{1+\frac{1}{3}}\right)$$

$$\phi_m = \sin^{-1}\left(\frac{2/3}{4/3}\right) = \sin^{-1}\left(\frac{1}{2}\right) = 30°$$

6.3 (a)

$G(s)$ of PID controller is

$$G(s) = K_P + \frac{K_i}{s} + sK_D$$

$$= K_P\left[1+\frac{K_i}{K_P s}+\frac{K_D s}{K_P}\right] = K_P\left[1+\frac{1}{T_i s}+T_D s\right]$$

6.4 (b)

(i) Integral controller improves the steady state response.

(ii) Derivative controller improves the transient response.

7. State Space Analysis

7.1 (a)

$$x_1(k+1) = x_2(k) \quad \text{... (i)}$$
$$x_2(k+1) = -\beta x_1(k) - \alpha x_2(k) + u(k) \quad \text{... (ii)}$$
$$y(k) = x_2(k) \quad \text{... (iii)}$$

From equation (i) and (ii)

$$x_1(k+2) = -\beta x_1(k) - \alpha x_1(k+1) + u(k)$$

$$\Rightarrow \quad c(k+2) = -\beta c(k) - \alpha c(k+1) + u(k)$$

$$\Rightarrow c(k+2) + \alpha c(k+1) + \beta c(k) = u(k)$$

8. Miscellaneous

8.1 (c)

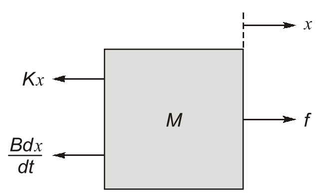
Small X/R gives linear speed torque characteristic. Large L/D gives less inertia and good acceleration characteristic.

8.2 (c)

Rotor of control transformer is made cylindrical in shape so that air gap is practically uniform.

8.3 (a)

This is a second order differential equation which means that there must be present all the three components in the system, i.e. either R, L and C or K, B and M.



Free body diagram of M in Fig. 1

In figure 1,

$$f - Kx - B\frac{dx}{dt} = M\frac{d^2x}{dt^2}$$

Or $$M\frac{d^2x}{dt^2} + B\frac{dx}{dt} + Kx = f \quad \text{... (i)}$$

In figure 2,

$$v(t) = Ri + \frac{Ldi}{dt} + \frac{q}{c}$$

Or $$v(t) = \frac{Ld^2q}{dt^2} + R\frac{dq}{dt} + \frac{q}{c} \quad \text{... (ii)}$$

Both the equations are symmetric to the given equation.

8.4 (d)

Equation for constant – N circle is

$$\left(x + \frac{1}{2}\right)^2 + \left(y - \frac{1}{2N}\right)^2 = \frac{N^2 + 1}{4N^2}$$

whose centre is $\left(\frac{-1}{2}, \frac{1}{2N}\right)$

and radius is $\frac{\sqrt{N^2 + 1}}{2N}$

8.5 (a)

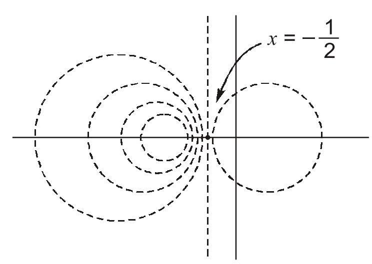
Equation for constant $-M$ circle is

$$\left(x + \frac{M^2}{M^2 - 1}\right)^2 + y^2 = \frac{M^2}{(M^2 - 1)^2}$$

whose centre is $\left(-\frac{M^2}{M^2 - 1}, 0\right)$

and radius is $\frac{M}{M^2 - 1}$

The constant $-M$ circle is the straight line at $x = -\frac{1}{2}$.



Locus of constant-M circles

■■■

2 Signals and Systems + DSP

1. Basics of Signals and Systems

1.1 Which one of the following pairs is NOT correctly matched? (input $x(t)$ and output $y(t)$).

(a) Unstable system: $\dfrac{dy(t)}{dt} - 0.1y(t) = x(t)$

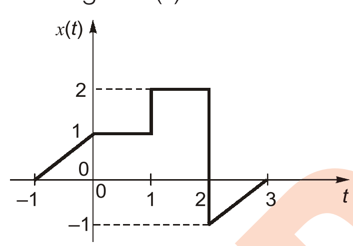
(b) Nonlinear system: $\dfrac{dy(t)}{dt} + 2t^2 y(t) = x(t)$

(c) Noncausal system: $y(t) = x(t + 2)$

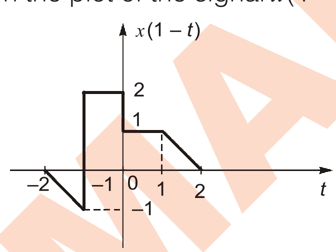
(d) Nondynamic system: $y(t) = 3x^2(t)$

[ESE-1999]

1.2 If a plot of signal $x(t)$ is as shown in the Figure,



then the plot of the signal $x(1 - t)$ will be

(a)


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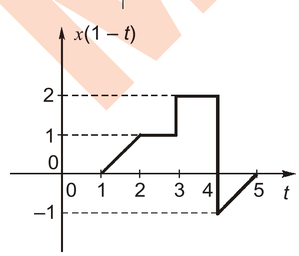

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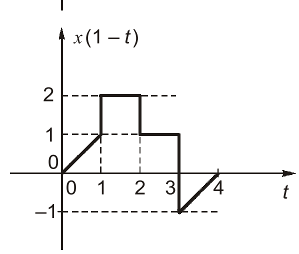

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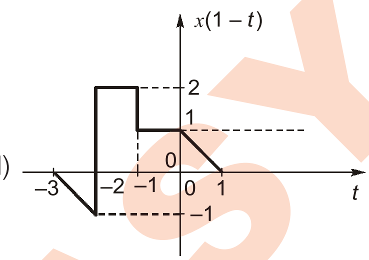
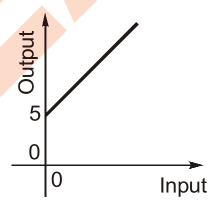


[ESE-1999]

1.3 Which one of the following input-output relationships is that of a linear system?

(a)


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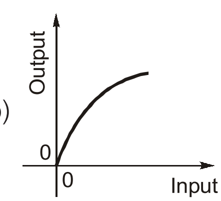

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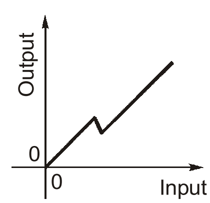

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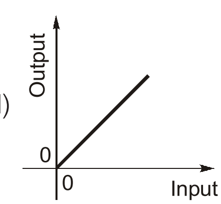


[ESE-1999]

1.4 The discrete-time equation $y(n + 1) + 0.5n\ y(n) = 0.5x\ (n + 1)$ is NOT attributable to a

(a) memoryless system

(b) time-varying system

(c) linear system

(d) causal system

[ESE-1999]

1.5 The period of the function $\cos[\pi/4(t - 1)]$ is

(a) 1/8 s (b) 8 s

(c) 4 s (d) 1/4 s

[ESE-1999]

1.6 Match **List-I** (Characteristic of $f(t)$) with **List-II** (Functions) and select the correct answer using the codes given below the lists:

List-I

A. $f(t)\,(1 - u(t)) = 0$

B. $f(t) + K\,df(t)/dt = 0$; K is a positive constant

C. $f(t) + K\dfrac{d^2f(t)}{dt^2} = 0$; K is a positive constant

D. $f(t)\,(g(t) - g(0)) = 0$; for any arbitrary $g(t)$

List-II

1. Decaying exponential
2. Growing exponential
3. Impulse
4. Causal
5. Sinusoid

Codes:

	A	B	C	D
(a)	4	1	5	3
(b)	1	4	5	3
(c)	4	2	5	1
(d)	2	5	4	1

[ESE-1999]

2. Continuous and Discrete Time LTI Systems

2.1 Figure-I and Figure-II show respectively the input $x(t)$ to a linear time-invariant system and the impulse response $h(t)$ of the system.

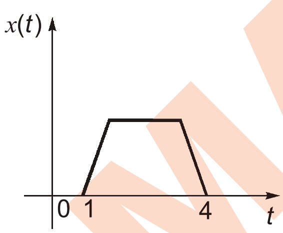


Figure I

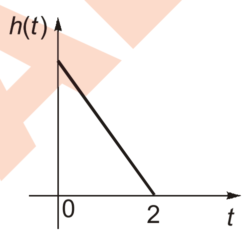


Figure II

The output of the system is zero everywhere except for the time-interval

(a) $0 < t < 4$ (b) $0 < t < 5$

(c) $1 < t < 5$ (d) $1 < t < 6$

[ESE-1999]

4. Continuous Time Fourier Transform

4.1 Match **List-I** (Fourier transform) with **List-II** (Functions of time) and select the correct answer using the codes given below the lists:

List-I	List-II
A. $\dfrac{\sin k\omega}{\omega}$	1. A constant
B. $e^{-j\omega d}$	2. Exponential function
C. $\dfrac{1}{(j\omega + 2)^2}$	3. t-multiplied exponential function
D. $k\delta(\omega)$	4. Rectangular pulse
	5. Impulse function

Codes:

	A	B	C	D
(a)	4	5	3	1
(b)	4	5	3	2
(d)	3	4	2	1
(d)	3	4	2	5

[ESE-1999]

5. Laplace Transform

5.1 Laplace transform of $\sin(\omega t + \alpha)$ is

(a) $\dfrac{\alpha}{s^2 + \alpha^2}\exp(s/\alpha\omega)$

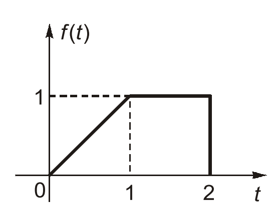
(b) $\dfrac{\omega}{s^2 + \omega^2}\exp(s/\alpha\omega)$

(c) $\dfrac{s}{s^2 + \alpha^2}\exp(s/\alpha\omega)$

(d) $\dfrac{\omega}{s^2 + \alpha^2}\exp(s/\alpha\omega)$

[ESE-1999]

5.2 The function $f(t)$ shown in the given figure will have Laplace transform as



(a) $\dfrac{1}{s^2} - \dfrac{1}{s}e^{-s} - \dfrac{1}{s^2}e^{-2s}$

(b) $\dfrac{1}{s^2}(1 - e^{-s} - e^{-2s})$

(c) $\dfrac{1}{s}(1 - e^{-s} - e^{-2s})$

(d) $\dfrac{1}{s^2}(1 - e^{-s} - se^{-2s})$

[ESE-1999]

5.3 Inverse Laplace transform of the function $\dfrac{2s+5}{s^2+5s+6}$ is

(a) $2\exp(-2.5\,t)\cos h\,0.5t$

(b) $\exp(-2t) - \exp(-3t)$

(c) 2 exp (–2.5*t*) sin h 0.5*t*
(d) 2 exp (–2.5*t*) cos 0.5*t*

[ESE-1999]

8. Z-Transform

8.1 **Assertion (A):** An LTI discrete system represented by the difference equation $y(n+2) - 5y(n+1) + 6y(n) = x(n)$ is unstable.

Reason (R): A system is unstable if the roots of the characteristic equation lie outside the unit circle.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-1999]

8.2 Consider the following statements regarding a linear discrete-time system

$$H(z) = \frac{z^2+1}{(z+0.5)(z-0.5)}$$

1. The system is stable.
2. The initial value $h(0)$ of the impulse response is –4.
3. The steady-state output is zero for a sinusoidal discrete time input of frequency equal to one-fourth the sampling frequency.

Which of these statements are correct?
(a) 1, 2 and 3 (b) 1 and 2
(c) 1 and 3 (d) 2 and 3

[ESE-1999]

■■■

Answers Signals and Systems + DSP

1.1	(b)	1.2	(a)	1.3	(d)	1.4	(a)	1.5	(b)	1.6	(a)	2.1	(d)	4.1	(a)	5.1	(*)
5.2	(d)	5.3	(a)	8.1	(a)	8.2	(c)										

Explanations Signals and Systems + DSP

1. Basics of Signals and Systems

1.1 (b)

(i) For the system to be stable, the roots of the characteristic equation should lie in the LHS of *s*-plane.

$$\frac{dy(t)}{dt} - 0.1y(t) = x(t)$$

$$\Rightarrow \quad \frac{Y(s)}{X(s)} = \frac{1}{s-0.1}$$

$\Rightarrow s = 0.1$ which is in RHS of *s*-plane, hence the system is unstable.

(ii) The system is linear if the response to $ax_1(t) + bx_2(t)$ is $ay_1(t) + by_2(t)$.

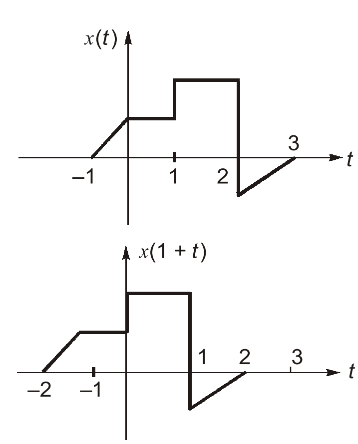
$$\frac{dy(t)}{dt} + 2t^2y(t) = x(t)$$

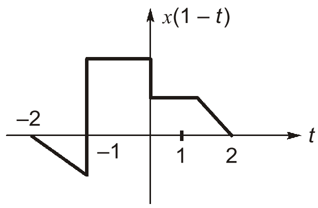
The condition of linearity is satisfied here, hence the system is linear.

(iii) A system is causal if the output at any time depends only on values of the input at the present time and in the past.

(iv) A system is said to be memoryless or static if its output for each value of the independent variable at a given time is dependent only on the input at the same time.

1.2 (a)





$x(1 + t)$ is the shifted version of $x(t)$ towards left by one unit. $x(1 – t)$ is the mirror image of $x(1 + t)$ along vertical axis.

1.3 (d)

A linear system, in continuous time or discrete time, is a system that possesses the important property of superposition.

A direct consequence of the superposition property is that, for linear systems, an input which is zero for all time results in an output which is zero for all time.

NOTE: Let $y_1(t)$ and $y_2(t)$ be the responses of a continuous time system to the inputs $x_1(t)$ and $x_2(t)$ respectively. Then the system is linear if:

(i) The response to $x_1(t) + x_2(t)$ is $y_1(t) + y_2(t)$.
$\Rightarrow$ Additivity property.

(ii) The response to $ax_1(t)$ is $ay_1(t)$, where a is any complex constant.
$\Rightarrow$ Scaling or homogeneity property.

1.4 (a)

Since the output for each value of the independent variable at a given time is not dependent on the input at the same time, hence the system is having memory. Therefore, the system is not attributable to a memoryless system.

NOTE: A system is said to be memoryless if its output for each value of the independent variable at a given time is dependent only on the input at the same time.

(i) Memoryless system is also called static system.

(ii) A system having memory is also called dynamic system.

1.5 (b)

$$f(t) = \cos\left[\frac{\pi}{4}(t-1)\right]$$

$$\text{Period} = \frac{2\pi}{\omega} = \frac{2\pi}{\pi/4} = 8 \text{ s}$$

1.6 (a)

(i) $f(t) + K\dfrac{df(t)}{dt} = 0$

Taking Laplace transform,

$(1 + Ks)\,F(s) = 0$

characteristic equation is $1 + Ks = 0$

complementary function C.F. $= e^{-t/K}$

which is decaying exponential.

(ii) $f(t) + \dfrac{Kd^2f(t)}{dt^2} = 0$

Its Laplace transform is

$(1 + Ks^2)\,F(s) = 0$

characteristic equation is $1 + Ks^2 = 0$

Roots are $s = \pm j\dfrac{1}{\sqrt{K}}$

C.F. $= \cos\dfrac{1}{\sqrt{K}}t + \sin\dfrac{1}{\sqrt{K}}t$

which is a sinusoid function.

(iii) $f(t)\,\{1 - u(t)\} = 0$

$\because$ $u(t) = 1$ for $t > 0$
$\quad\quad 0$ for $t < 0$

So for $t < 0$, $f(t) = 0$

Therefore, $f(t)$ is a causal function.

2. Continuous and Discrete Time LTI Systems

2.1 (d)

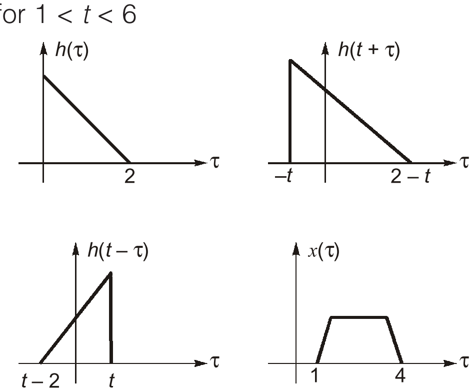
$$y(t) = \int_{-\infty}^{\infty} x(\tau)\,h(t-\tau)\,d\tau$$

$y(t) = 0$ when $t < 1$

$y(t) = 0$ when $t - 2 > 4$ or $t > 6$

so, $y(t) = 0$ for $1 < t$ and $t > 6$

so, $y(t)$ is zero everywhere except for $1 < t < 6$



4. Continuous Time Fourier Transform

4.1 (a)

Signal $f(t)$	Fourier Transform $F(\omega)$
1	$2\pi\delta(\omega)$
$\text{rect}\left(\frac{t}{\tau}\right)$	$\tau\,\text{sinc}\left(\frac{\omega\tau}{2}\right)$
$t^n e^{-at}u(t)$	$\frac{n!}{(a+j\omega)^{n+1}}$
$\delta(t)$	1

Time shifting property:

If $f(t) \xleftrightarrow{FT} F(\omega)$

then $f(t-t_0) \xleftrightarrow{FT} e^{-j\omega t_0}F(\omega)$

so $\delta(t-d) \xleftrightarrow{FT} e^{-j\omega d}$

5. Laplace Transform

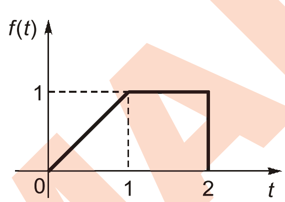
5.1 (*)

$$f(t) = \sin(\omega t + \alpha)$$

$$F(s) = \exp\left(\frac{\alpha}{\omega}\cdot s\right)\cdot LT\{\sin\omega t\}$$

$$F(s) = \frac{\omega}{s^2+\omega^2}\exp\left(\frac{\alpha}{\omega}\cdot s\right)$$

5.2 (d)



$$f(t) = tu(t) - (t-1)\,u(t-1) - u(t-2)$$

$$\Rightarrow \quad F(s) = \frac{1}{s^2} - \frac{e^{-s}}{s^2} - \frac{e^{-2s}}{s}$$

$$\Rightarrow \quad F(s) = \frac{1}{s^2}(1 - e^{-s} - s\,e^{-2s})$$

5.3 (a)

$$F(s) = \frac{2s+5}{s^2+5s+6} = \frac{1}{s+2} + \frac{1}{s+3}$$

$$\Rightarrow \quad f(t) = e^{-2t} + e^{-3t}$$

$$= 2e^{-2.5t}\left[\frac{e^{0.5t}+e^{-0.5t}}{2}\right]$$

$$= 2e^{-2.5t}\cos h\,0.5t$$

8. Z-Transform

8.1 (a)

Difference equation is

$y(n+2) - 5y(n+1) + 6y(n) = x(n)$

Taking z-transform,

$(z^2 - 5z + 6)\;Y(z) = X(z)$

$$\frac{Y(z)}{X(z)} = \frac{1}{z^2-5z+6} = H(z)$$

where $H(z)$ is transfer function

$$H(z) = \frac{1}{(z-2)\,(z-3)}$$

The characteristic equation has roots

$z = 2, 3.$

Since the characteristic equation has the roots outside the unit circle, hence the system is unstable.

8.2 (c)

(i) Characteristic equation is $(z+0.5)(z-0.5) = 0$.

Its roots are $z = 0.5, -0.5$.

Since both roots are inside the unit circle, hence the system is stable.

(ii) $$h(0) = \lim_{z\to\infty} H(z)$$

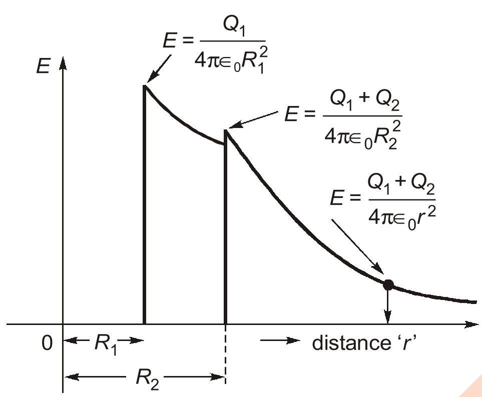
$$= \lim_{z\to\infty}\frac{z^2+1}{(z+0.5)(z-0.5)} = 1$$

■■■

3 Electromagnetics

1. Basic of Electromagnetics

1.1 The given figure represents the variation of electric field 'E'



(a) due to a spherical volume charge $Q = Q_1 + Q_2$
(b) due to two concentric shells of charges Q_1 and Q_2 uniformly distributed over spheres of radii R_1 and R_2
(c) due to two point charges Q_1 and Q_2 located at any two points 'r' ($= R_1$ and R_2)
(d) in a single spherical shell of charges Q uniformly distributed, $Q = Q_1 + Q_2$

[ESE-1999]

1.2 Two small diameter 5 g dielectric balls can slide freely on a vertical nonconducting thread. Each ball carries a negative charge of 2 μC. If the lower ball is restrained from moving, then the separation between the two balls will be

(a) 8570 mm (b) 857 mm
(c) 85.7 mm (d) 8.57 mm

[ESE-1999]

1.3 Solutions of Laplace's equation, which are continuous through the second derivative, are called

(a) Bessel functions
(b) odd functions
(c) harmonic functions
(d) fundamental functions [ESE-1999]

1.4 Charge needed within a unit sphere centred at the origin for producing a potential field,

$V = -\frac{6r^5}{\epsilon_o}$, for $r \le 1$ is

(a) 12π C (b) 60π C
(c) 120π C (d) 180π C [ESE-1999]

1.5 The region between two concentric conducting cylinders with radii of 2 and 5 cm contains a volume charge distribution of $-10^{-8}(1 + 10r)$ C/m^3. If E_r and V both are zero at the inner cylinder and $\epsilon = \epsilon_0$, the potential V at the outer cylinder will be

(a) 0.506 V (b) 5.06 V
(c) 50.6 V (d) 506 V [ESE-1999]

1.6 **Assertion (A):** Net charge within a conductor is always zero.

Reason (R): The conductor has a very large number of free electrons.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true [ESE-1999]

2. Uniform Plane Waves

2.1 A TEM wave impinges obliquely on a dielectric-dielectric boundary with $\epsilon_{r_1} = 2$ and $\epsilon_{r_2} = 1$. The angle of incidence for total reflection is:

(a) 30° (b) 60°
(c) 45° (d) 90°

[ESE-1999]

2.2 The function $F = e^{-\alpha z} \sin\frac{\omega}{v}(x - vt)$ satisfies the wave equation $\nabla^2 F = \frac{F}{c^2}$ provided

(a) $v = c\left(1+\frac{\alpha^2 c^2}{\omega^2}\right)^{-1/2}$

(b) $v = c(1 + \omega^2\alpha^2 c)^{-1/2}$

(c) $v = c\omega(\alpha^2 c^2 - 1)^{-1/2}$

(d) $v = \frac{1}{c}\left(1+\frac{\omega^2 c^2}{\alpha^2}\right)^{-1/2}$ [ESE-1999]

2.3 A plane electromagnetic wave is travelling in an unbounded loss-less dielectric having $\mu_r = 1$ and $\epsilon_r = 4$. The time average Poynting vector of the wave is 5 W/m^2. The phase velocity v_p (assuming velocity of light as 3×10^8 m/s) is

(a) 1.5×10^8 m/s (b) 3×10^8 m/s

(c) 2.5×10^8 m/s (d) 0.5×10^8 m/s

[ESE-1999]

2.4 When a plane wave is incident normally from dielectric '1'(μ_0, ϵ_1) onto dielectric '2' (μ_0, ϵ_2), the electric field of the transmitted wave is –2 times the electric field of the reflected wave. The ratio ϵ_2/ϵ_1 is

(a) 0.5 (b) 1

(c) 2 (d) 4

[ESE-1999]

2.5 If for the transmission of a parallel polarized wave from a dielectric medium of permittivity ϵ_1 into a dielectric medium of permittivity ϵ_2, there exists a value of the angle of incidence θ_p for which the reflection coefficient is zero, then

(a) $\tanh\theta_p = \sqrt{\epsilon_1/\epsilon_2}$

(b) $\tan\theta_p = \sqrt{\epsilon_1/\epsilon_2}$

(c) $\tan\theta_p = \sqrt{\epsilon_2/\epsilon_1}$

(d) $\tanh\theta_p = \sqrt{\epsilon_2/\epsilon_1}$

[ESE-1999]

2.6 For an elliptically polarized wave incident on the interface of a dielectric at the Brewster angle, the reflected wave will be

(a) elliptically polarized

(b) linearly polarized

(c) right circularly polarized

(d) left circularly polarized

[ESE-1999]

2.7 For electromagnetic wave propagation in free space, the free space is defined as

(a) $\sigma = 0, \epsilon = 1, \mu \neq 1, \vec{p} \neq 0, \vec{j} = 0$

(b) $\sigma = 0, \epsilon = 1, \mu = 1, \vec{p} = 0, \vec{j} = 0$

(c) $\sigma \neq 0, \epsilon > 1, \mu < 1, \vec{p} \neq 0, \vec{j} = 0$

(d) $\sigma = 0, \epsilon = 1, \mu = 1, \vec{p} \neq 0, \vec{j} \neq 0$

[ESE-1999]

2.8 A plane wave of 10 GHz is incident normally on a dielectric plate of 3 mm thickness. If the phase shift on transmission through the sheet is 90°, then the dielectric constant is

(a) 2.5 (b) 3.25

(c) 4.5 (d) 6.25

[ESE-1999]

3. Transmission Lines

3.1 A 50 Ω characteristic impedance line is connected to a load which shows a reflection coefficient of 0.268. If V_{in} = 15 V, then the net power delivered to the load will be

(a) 0.139 W (b) 1.39 W

(c) 0.278 W (d) 2.78 W [ESE-1999]

3.2 For a transmission line with homogeneous dielectric, the capacitance per unit length is 'C', the relative permittivity of the dielectric is 'ϵ_r' and velocity of light in free space is 'v'. The characteristic impedance Z_0 is equal to

(a) $\frac{\epsilon_r}{vC}$ (b) $\frac{\epsilon_r}{\sqrt{vC}}$

(c) $\frac{\sqrt{\epsilon_r}}{vC}$ (d) $\sqrt{\frac{\epsilon_r}{vC}}$

[ESE-1999]

3.3 It is desired to reduce the reflection at an air porcelain by use of λ/4 plate. (For porcelain $\mu = \mu_0$ and $\epsilon_r = 2$). The thickness of the polystyrene plate required at 10 GHz will be

(a) 5.039 cm (b) 50.39 cm

(c) 0.5039 cm (d) 0.05039 cm

[ESE-1999]

3.4 A quarter-wave transformer is used for matching a load of 225 ohms connected to a transmission line of 256 ohms in order to reduce the SWR along the line to 1. The characteristic impedance (in ohms) of the transformer is
(a) 225 (b) 240
(c) 256 (d) 273
[ESE-1999]

3.5 For distortionless transmission through a channel, the channel should be such that
(a) its attenuation response is an even function and phase response is an odd function of frequency
(b) its attenuation response is flat and phase response is linear with frequency
(c) the ratio of line inductance to line capacitance is constant
(d) its termination is by a matched impedance
[ESE-1999]

3.6 When VSWR is 3, the magnitude of the reflection coefficient will be
(a) 1/4 (b) 1/3
(c) 1/2 (d) 1 [ESE-1999]

3.7 A coaxial *RF* cable has the characteristic impedance of 50 Ω and a nominal capacitance of 40 pF/m. The inductance of the cable is
(a) 1 μH/m (b) 10 μH/m
(c) 0.1 μH/m (d) 0.0 μH/m
[ESE-1999]

4. Waveguides

4.1 A rectangular waveguide $2.29 \text{ cm} \times 1.02 \text{ cm}$ operates at a frequency of 11 GHz in TE_{10} mode. If the maximum potential gradient of the signal is 5 kV/cm, then the maximum power handling capacity of the waveguide will be
(a) 31.11 mW (b) 31.11 W
(c) 31.11 kW (d) 31.11 MW
[ESE-1999]

4.2 When the phase velocity of an electromagnetic wave depends on frequency in any medium, the phenomenon is called
(a) scattering (b) polarization
(c) absorption (d) dispersion
[ESE-1999]

5. Antennas and Radar

5.1 A dipole antenna, with some excitation in free space was radiating a certain amount of the power. If this antenna is immersed in a lake where water is non-magnetic and non-dissipative but has a dielectric constant of 81, the radiated power with the same excitation will
(a) decrease to finite non-zero value
(b) remain the same
(c) increase
(d) decrease to zero
[ESE-1999]

5.2 A broadside array operating at 100 cm wavelength consists of 4 half-wave dipoles spaced 50 cm apart. Each element carries radio frequency current in the same phase and of magnitude 0.5 A. The radiated power will be
(a) 146 W (b) 73 W
(c) 36.5 W (d) 18.25 W
[ESE-1999]

5.3 An antenna has a gain of 44 dB. Assuming that the main beam of the antenna is circular in cross-section, the beam width will be
(a) 0.4456° (b) 1.4456°
(c) 2.4456° (d) 3.4456°
[ESE-1999]

5.4 A dipole antenna of λ/8 length has an equivalent total loss resistance of 1.5 Ω. The efficiency of the antenna is:
(a) 0.89159% (b) 8.9159%
(c) 89.159% (d) 891.59%
[ESE-1999]

5.5 **Assertion (A):** In a small flare angle pyramidal horn excited by a TE_{10} rectangular waveguide, the operative field distribution is also very nearly that of TE_{10} mode.
Reason (R): In a small flare angle horn, the throat acts as a mode filter.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true [ESE-1999]

5.6 For an aperture antenna of aperture dimension *D* and wavelength of radiation from the antenna λ, the far-field is at a distance greater than

(a) $D^2/2\lambda$ (b) $2D^2/\lambda$
(c) D^2/λ (d) $(2D)^2/\lambda$

[ESE-1999]

5.7 Consider the following statements about advantages and disadvantages of offset parabolic reflector antenna:

1. It reduces aperture blocking but degrades sidelobe level.
2. It can be used as a multibeam or dual polarised antenna.
3. A linearly polarised illumination causes no cross-polarised components in the radiation pattern.
4. It improves isolation between reflector and primary feed.

Which of these statements are correct?

(a) 1 and 2 (b) 3 and 4
(c) 1 and 3 (d) 2 and 4

[ESE-1999]

5.8 In a radar system, if the peak transmitted power is increased by a factor of 16 and the antenna diameter is increased by a factor of 2, then the maximum range will increase by a factor of

(a) 16 (b) 8
(c) 4 (d) $\sqrt{8}$

[ESE-1999]

5.9 The electric field at a point from a transmitter radiating a certain power is 2.5 mV/m. If the transmitter power is doubled, the yield strength at that point will be about

(a) 2.5 mV/m (b) 3.5 mV/m
(c) 5 mV/m (d) 10 mV/m

[ESE-1999]

5.10 **Assertion (A):** One of the functions of the radar beacon is to identify itself.

Reason (R): Radar beacon cannot operate over a large distance.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-1999]

5.11 For identifying a radar target in a non-lossy medium, the range of the target is to be doubled, the *RF* power radiated must be increased by

(a) 2 times (b) 4 times
(c) 8 times (d) 16 times

[ESE-1999]

■■■

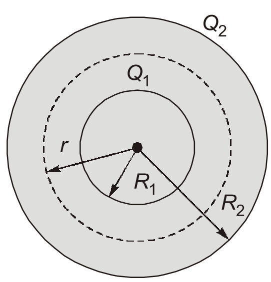
Answers Electromagnetics

1.1	(b)	1.2	(b)	1.3	(c)	1.4	(c)	1.5	(a)	1.6	(b)	2.1	(c)	2.2	(a)	2.3	(a)
2.4	(d)	2.5	(c)	2.6	(b)	2.7	(b)	2.8	(d)	3.1	(b)	3.2	(c)	3.3	(c)	3.4	(b)
3.5	(b)	3.6	(c)	3.7	(c)	4.1	(c)	4.2	(d)	5.1	(c)	5.2	(c)	5.3	(b)	5.4	(c)
5.5	(a)	5.6	(b)	5.7	(a)	5.8	(c)	5.9	(b)	5.10	(c)	5.11	(d)				

Explanations Electromagnetics

1. Basic of Electromagnetics

1.1 (b)



where, $r < R$

$E = 0$ as charge enclosed is zero

Applying Gauss Law for

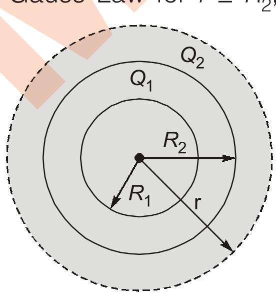
$R_1 \le r < R_2$,

$$\oiint_s \vec{E}\cdot d\vec{s} = \frac{Q_1}{\epsilon_o}$$

$$E\cdot 4\pi r^2 = \frac{Q_1}{\epsilon_o}$$

$$E = \frac{Q_1}{4\pi\epsilon_o r^2}$$

Applying Gauss Law for $r \ge R_2$,



$$\Rightarrow \quad \oiint_s \vec{E}\cdot d\vec{s} = \frac{Q_1+Q_2}{\epsilon_o}$$

$$E\cdot 4\pi r^2 = \frac{Q_1+Q_2}{\epsilon_o}$$

$$E = \frac{Q_1+Q_2}{4\pi\epsilon_o r^2}$$

Plot of E vs r will be the same as drawn in the question.

1.2 (b)

At equilibrium, since the lower ball does not move, Coulombic force will be equal to gravitational force.

$$\frac{q_1 q_2}{4\pi\epsilon_o r^2} = mg$$

where r is the separation between the two balls.

$$\frac{2\times10^{-6}\times2\times10^{-6}\times9\times10^{9}}{r^2} = 5\times10^{-3}\times9.8$$

$$\Rightarrow \quad r^2 = 0.7347$$

$$\Rightarrow \quad r = 0.857\text{ m} = 857\text{ mm}$$

1.3 (c)

Laplace operator is second order derivative with space.

Continuous means giving same function after second order derivative which means it is harmonic.

1.4 (c)

By Poisson's equation:

$$\nabla^2 V = -\frac{\rho_v}{\varepsilon_0}$$

$$\frac{1}{r^2}\left[\frac{\partial}{\partial r}r^2\frac{\partial}{\partial r}\left(-\frac{6r^5}{\varepsilon_0}\right)\right] = -\frac{\rho_v}{\varepsilon_0}$$

$$\rho_v = 30r^3$$

$$Q = \iiint \rho_v\,dv$$

$$= \int_{r=0}^{1}\int_{\theta=0}^{\pi}\int_{\phi=0}^{2\pi} 180r^3\cdot r^2\sin\theta\,d\phi\,d\theta\,dr$$

$$= 180\frac{r^6}{6}\Big|_0^1 \cdot (-\cos\theta)\Big|_0^\pi \times 2\pi$$

$$= 180 \times \frac{1}{6} \times 2 \times 2\pi = 120\pi C$$

1.5 (a)

Applying $\nabla^2 V = -\frac{\rho_v}{\in}$ Poisson's equation

V is a function of ρ.

$$\nabla^2 V = \frac{1}{\rho}\frac{\partial}{\partial\rho}\left(\rho\frac{\partial V}{\partial\rho}\right) = -\frac{\rho_v}{\in}$$

$$\rho_v = -10^{-8}(1 + 10\rho)$$

All initial conditions on the inner cylinder being zero (V and E both).

Solving for V gives 0.5 V.

1.6 (b)

The conductor has a very large number of free electrons and because it is electrical neutral the net charge within a conductor is always zero.

2. Uniform Plane Waves

2.1 (c)

For total reflection, angle of refraction $\theta_r = 90°$.

$$\frac{\sin\theta_i}{\sin\theta_r} = \sqrt{\frac{\in_{r2}}{\in_{r1}}}$$

$$\Rightarrow \quad \sin\theta_i = \sqrt{\frac{\in_{r2}}{\in_{r1}}} \cdot \sin 90°$$

$$\Rightarrow \quad \sin\theta_i = \frac{1}{\sqrt{2}}$$

$$\Rightarrow \quad \theta_i = 45°$$

⇒ Angle of incidence $\theta_i = 45°$ for total reflection.

2.2 (a)

$$\nabla^2 F = \frac{\partial^2 F}{\partial x^2} + \frac{\partial^2 F}{\partial z^2}$$

$$F = e^{-\alpha z}\sin\frac{\omega}{V}(x - Vt)$$

$$\frac{\partial F}{\partial x} = \frac{\omega}{V}e^{-\alpha z}\cos\frac{\omega}{V}(x - Vt)$$

$$\frac{\partial^2 F}{\partial x^2} = -\frac{\omega^2}{V^2}e^{-\alpha z}\sin\frac{\omega}{V}(x - Vt)$$

$$\frac{\partial F}{\partial z} = -\alpha e^{-\alpha z}\sin\frac{\omega}{V}(x - Vt)$$

$$\frac{\partial^2 F}{\partial z^2} = \alpha^2 e^{-\alpha z}\sin\frac{\omega}{V}(x - Vt)$$

$$\therefore \quad \nabla^2 F = -\frac{\omega^2}{V^2}e^{-\alpha z}\sin\frac{\omega}{V}(x - Vt) + \alpha^2 e^{-\alpha z}\sin\frac{\omega}{V}(x - Vt)$$

$$\Rightarrow \quad \nabla^2 F = e^{-\alpha z}\sin\frac{\omega}{V}(x - Vt)\left[-\frac{\omega^2}{V^2} + \alpha^2\right]$$

$$\Rightarrow \quad \nabla^2 F = F\left[\alpha^2 - \frac{\omega^2}{V^2}\right]$$

$$\therefore \quad \alpha^2 - \frac{\omega^2}{V^2} = \frac{1}{C^2}$$

$$\Rightarrow \quad \alpha^2 - \frac{1}{C^2} = \frac{\omega^2}{V^2}$$

$$\Rightarrow \quad \frac{\alpha^2 C^2 - 1}{C^2} = \frac{\omega^2}{V^2}$$

$$\Rightarrow \quad V = \frac{\omega C}{(\alpha^2 C^2 - 1)^{1/2}} = \omega C(\alpha^2 C^2 - 1)^{-1/2}$$

2.3 (a)

Phase velocity

$$v_p = \frac{c}{\sqrt{\in_r}} = \frac{3 \times 10^8}{\sqrt{4}}$$

$$= 1.5 \times 10^8 \text{ m/s}$$

2.4 (d)

Given that

$$E_t = -2E_r$$

where E_t = Electric field of transmitted wave

E_r = Electric field of reflected wave

Or $\quad \frac{E_t}{E_i} = -\frac{2E_r}{E_i}$

where E_i = Electric field of incident wave.

But $\quad \frac{E_t}{E_i} = \frac{2\eta_2}{\eta_2 + \eta_1}$

and $\quad \frac{E_r}{E_i} = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1}$

So, $\quad \frac{2\eta_2}{\eta_2 + \eta_1} = -2\frac{(\eta_2 - \eta_1)}{\eta_2 + \eta_1}$

$$\Rightarrow \quad \eta_2 = -\eta_2 + \eta_1$$

$$\Rightarrow \quad \frac{\eta_1}{\eta_2} = 2$$

But $\quad \eta \propto \frac{1}{\sqrt{\epsilon}}$

So, $\quad \sqrt{\frac{\epsilon_2}{\epsilon_1}} = 2$

or $\quad \frac{\epsilon_2}{\epsilon_1} = 4$

2.5 (c)

Brewster's angle: This is the angle of incidence for parallel polarized wave for which the reflection coefficient is zero and the electromagnetic wave is transmitted completely in the second medium.

$$\tan \theta_B = \sqrt{\frac{\epsilon_2}{\epsilon_1}}$$

where, θ_B = Brewster's angle

2.6 (b)

Since the wave is incident at Brewster angle, the component normal to the interface will be the only component which is parallel to the interface. Hence the reflected wave is linearly polarized.

2.7 (b)

Free space properties are

$\sigma = 0$ conductivity

$\mu_R = \epsilon_R = 1$

$\bar{p} = 0$ dipole moment

$\bar{j} = 0$ current density

2.8 (d)

Phase difference $= \frac{2\pi}{\lambda}$. Path difference

$$90 = \frac{2\times 180}{\lambda}\times 3\times 10^{-3}$$

$$\Rightarrow \quad \lambda = 12 \times 10^{-3} \text{ m}$$

$$v = \frac{c}{\sqrt{\epsilon_r}} = \lambda f$$

$$\frac{3\times 10^8}{\sqrt{\epsilon_r}} = 12 \times 10^{-3} \times 10 \times 10^9$$

$$\Rightarrow \quad \sqrt{\epsilon_r} = 2.5$$

$$\Rightarrow \quad \epsilon_r = 6.25$$

3. Transmission Lines

3.1 (b)

Load, $\quad Z_L = Z_o\left(\frac{1+|\Gamma|}{1-|\Gamma|}\right) = 50\left(\frac{1+0.268}{1-0.268}\right)$

$$\Rightarrow \quad Z_L = 86.612\ \Omega$$

Reflected voltage,

$$V_r = |\Gamma| V_{in} = 0.268 \times 15 = 4.02 \text{ V}$$

Voltage across load,

$$V_L = V_{in} - V_r = 15 - 4.02$$

$$\Rightarrow \quad V_L = 10.98 \text{ V}$$

Net power delivered to the load,

$$P_L = \frac{V_L^2}{R_L} = \frac{(10.98)^2}{86.612} = 1.39 \text{ W}$$

3.2 (c)

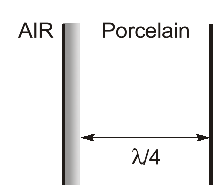
$$\frac{v}{\sqrt{\epsilon_r}} = \frac{1}{\sqrt{LC}} \quad \text{...(i)}$$

$$Z_o = \sqrt{\frac{L}{C}} \quad \text{...(ii)}$$

$$\frac{vZ_o}{\sqrt{\epsilon_r}} = \frac{1}{C}$$

$$\Rightarrow \quad Z_o = \frac{\sqrt{\epsilon_r}}{vC}$$

3.3 (c)

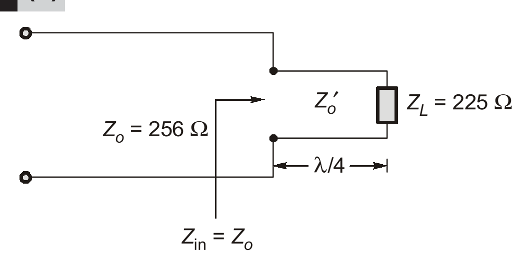


The porcelain plate of $\lambda/4$ thickness reduces reflections similar to a quarterwave transformer.

$$\text{Thickness} = \frac{\lambda}{4} = \frac{3\times 10^8}{\sqrt{\epsilon_R}\times 10\times 10^9}\times\frac{1}{4}$$

$$= 0.53 \text{ cm}$$

3.4 (b)



Characteristic impedance of QWT

$$Z_o' = \sqrt{Z_o Z_L}$$

$$= \sqrt{256 \times 225} = 16 \times 15 = 240\ \Omega$$

3.5 (b)

Distortionless when $LG = RC$

or $\alpha = \sqrt{RG}$ and $\beta = \omega\sqrt{LC}$

when calculated from γ.

α is constant and independent of frequency.

β is linear function of frequency.

3.6 (c)

Reflection coefficient

$$|\Gamma| = \frac{\text{VSWR}-1}{\text{VSWR}+1}$$

$$\Rightarrow \quad |\Gamma| = \frac{3-1}{3+1}$$

$$\Rightarrow \quad |\Gamma| = \frac{2}{4} = \frac{1}{2}$$

3.7 (c)

Characteristic impedance

$$Z_o = \sqrt{\frac{L}{C}}$$

$$\Rightarrow \quad L = CZ_0^2$$

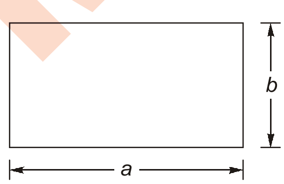
$$\Rightarrow \quad L = 40 \times 10^{-12} \times (50)^2$$

$$\Rightarrow \quad L = 0.1\ \mu\text{H/m}$$

4. Waveguides

4.1 (c)

$$f_c = \frac{3\times 10^{10}}{2\times 2.29} = 6.55\ \text{GHz}$$



Maximum power handling capacity of the waveguide for the TE mode is

$$P = \frac{E_m^2}{4\eta} \cdot ab\ \text{W}$$

(Maximum power when voltage is half of input)

$$= \frac{E_m^2}{4\left(\frac{\eta_o}{\sqrt{1-(f_c/f)^2}}\right)} \cdot ab$$

$$= \frac{\sqrt{1-(f_c/f)^2}}{4\eta_o} \cdot E_m^2 \cdot ab$$

$$= \frac{\sqrt{1-\left(\frac{6.55}{11}\right)^2}}{4\times 120\pi} \times (5\times 10^5)^2 \times 2.29 \times 1.02 \times 10^{-4}$$

$$= 31.11\ \text{kW}$$

4.2 (d)

V_p depends on ω means

β depends on ω^2

i.e. non-linear function of $\beta(\omega)$

5. Antennas and Radar

5.1 (c)

$$E_\theta = \frac{I_m}{2}\frac{dl}{\lambda}\frac{\sin\theta}{r}\eta$$

$$H_\phi = \frac{I_m}{2}\frac{dl}{\lambda}\frac{\sin\theta}{r}$$

$$\text{Power} \propto \frac{\eta}{\lambda^2}$$

$$\eta = \sqrt{\frac{\mu}{\epsilon}}\ ;\ \beta = \omega\sqrt{\mu\epsilon} = \frac{2\pi}{\lambda}$$

$$\text{Power} \propto \epsilon$$

5.2 (c)

Radiation resistance of half-wave dipole

$$R_{rad} = 73\ \Omega$$

Radiated power,

$$P_r = I_{rms}^2 \cdot R_{rad}$$

$$P_r = 4\times\left(\frac{0.5}{\sqrt{2}}\right)^2 \times 73 = 36.5\ \text{W}$$

5.3 (b)

$$\text{Gain} = \frac{4\pi}{\theta_{HPBW}\times\phi_{HPBW}} = \frac{4\pi}{(\theta_{HPBW})^2}$$

$$\text{Gain} = 44\ \text{dB} = 10^{4.4}$$

In degrees $4\pi = 4 \times 3.14 \times 57° \times 57°$

$$\text{Gain} = 10^{4.4} = \frac{40800}{(\theta_{HPBW})^2}$$

$$\theta_{HPBW} = 1.42°$$

5.4 (c)

$$\text{Efficiency} = \frac{W_r}{W_{in}} = \frac{\text{Out power radiated}}{\text{Input power}}$$

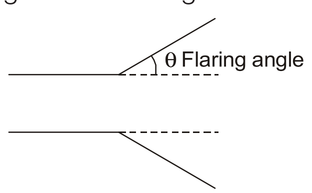
$$= \frac{I^2 R_r}{I^2 R_r + I^2 R_l} = \frac{R_r}{R_r + R_l}$$

$\lambda/8$ antenna $R_r = 18.25\ \Omega$

$$\text{Efficiency} = \frac{18.25}{19.75} \cong 92\%$$

5.5 (a)

Flare angle is mouth angle of the horn.



Smaller flare angle means lesser dispersion and scattering and hence field is most likely to be TE_{10}.
Mode filter means eliminating other modes other than given input mode TE_{10}. Narrow flare angle is therefore a mode filter.

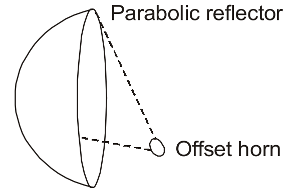
5.6 (b)

To measure the antennas performance in any aspect the near field or $\frac{1}{r^2}$ and $\frac{1}{r^3}$ have to be neglected. The radiation field $\frac{1}{r}$ term should be strong enough ignoring $\frac{1}{r^2}$ and $\frac{1}{r^3}$.
This distance is called as Fraunhofer zone where measurements are carried.

$$r > \frac{2D^2}{\lambda}$$

Where D is the biggest dimension of the antenna.

5.7 (a)



Offset feed is a mechanism where the feed horn placed below the conductor and focussed on the parabolic reflector.
It is used to reduce aperture blocking and use of two polarizations from two sides.

5.8 (c)

$$R_{max} = \left[\frac{P_t A_e^2 \sigma}{4\pi\lambda^2 S_{min}}\right]^{1/4}$$

$$\Rightarrow \quad R_{max} \propto [P_t \cdot A_e^2]^{1/4}$$

$$\Rightarrow \quad R_{max} \propto [P_t \cdot D^4]^{1/4}$$

$$\Rightarrow \quad R'_{max} = [16 \times (2)^4]^{1/4} R_{max}$$

$$\Rightarrow \quad R'_{max} = 4\, R_{max}$$

5.9 (b)

$$P \propto E^2$$

$$\Rightarrow \quad E \propto \sqrt{P}$$

$$\Rightarrow \quad \frac{E_2}{E_1} = \sqrt{\frac{P_2}{P_1}} = \sqrt{2}$$

$$\Rightarrow \quad E_2 = 2.5 \times \sqrt{2}$$

$$\Rightarrow \quad E_2 = 3.5 \text{ mV/m}$$

5.11 (d)

$$P_t \propto (R)^4$$

$$P_r = \frac{P_t G_t A_e \sigma}{(4\pi)^2 R^4}$$

$$\Rightarrow \quad P_t \propto R^4$$

■■■

4 Computer Organization and Architecture

2. I/O Organisation and Pipelining

2.1 The method used to transfer data from I/O units to memory by suspending the memory-CPU data transfer for one memory cycle is called
(a) I/O spooling (b) cycle stealing
(c) line conditioning (d) demand paging
[ESE-1999]

3. Memory Organisation

3.1 The principle of locality of reference justifies the use of
(a) interrupts (b) DMA
(c) virtual memory (d) cache memory
[ESE-1999]

3.2 The access time of a word in a 4 MB main memory is 100 ns. The access time of a word in a 32 kB data cache memory is 10 ns. The average data cache hit ratio is 0.95. The effective memory access time is
(a) 9.5 ns (b) 14.5 ns
(c) 20 ns (d) 95 ns
[ESE-1999]

4. Data Representation and Programming

4.1 Consider the following features:
1. Negative operands cannot be used.
2. When immediate operand changes, the program should be reassembled.
3. The program is difficult to read.
4. The size of operand is restricted by word length of the computer.

Disadvantages of immediate addressing include
(a) 1 and 2 (b) 2 and 4
(c) 2 and 3 (d) 1 and 4
[ESE-1999]

4.2 **Assertion (A):** The top down structured programming should be used for developing programs.
Reason (R): The top down structured programming methodology enables us to get readable and easily provable programs.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true [ESE-1999]

4.3 Consider the following statements:
1. An assembly language program runs faster than a high level language program to produce the desired result.
2. An assembler which runs on a computer for which it produces object codes is called a resident assembler.
3. A cross-assembler is an assembler that runs on a computer than that for which it provides machine codes.
4. A one-pass assembler reads the assembly language programs only once.

Which of these statements are correct?
(a) 1, 2 and 3 (b) 2, 3 and 4
(c) 1 and 4 (d) 1, 2, 3 and 4
[ESE-1999]

4.4 The software that transfers the object program from secondary memory to the main memory is called
(a) assembler (b) loader
(c) linker (d) task builder
[ESE-1999]

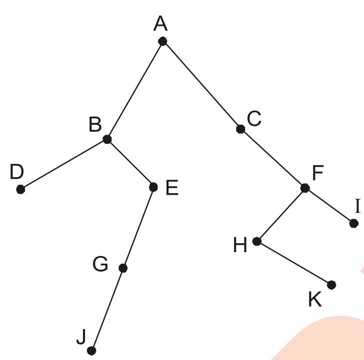
4.5 **Assertion (A):** The ‘do-while’ statements is used less frequently than the ‘while’ statement.
Reason (R): For most applications, it is more natural to test for continuation of a loop at the beginning rather than at the end of the loop.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true [ESE-1999]

5. Data Structures

5.1 The expression for the infix equivalent of the prefix form of $+ - * \uparrow ABCD/E/F + GH$ will be
(a) $A^{B*C} - D + E / F / G + H$
(b) $A^{B} * C - D + E / F / G + H$
(c) $A^{B} * C - D + E / F / (G + H)$
(d) $A^{B} * C - D + E / (F / (G + H))$ [ESE-1999]

5.2 If the given binary tree is traversed in post-order



then the order of nodes visited is
(a) J G E D B K H I F C A
(b) D B J G E A K H F I C
(c) D J G E B K H I F C A
(d) A B D E G J C F H K I [ESE-1999]

7. Miscellaneous

7.1 A PASCAL function is defined as calc (var A: real; B: real): real; begin
X : = 3.0;
Y : = 3.0;
calc: = 5.0*A+(B – A);
end;
If this function was called
X : = 7.0;
Y : = 1.0;
R : = calc (X, Y);
the value of R would be
(a) 15 (b) 29
(c) 13 (d) 31
[ESE-1999]

■■■

Answers Computer Organization and Architecture

2.1 (b) 3.1 (d) 3.2 (b) 4.1 (b) 4.2 (d) 4.3 (d) 4.4 (b) 4.5 (a) 5.1 (d)
5.2 (c) 7.1 (b)

Explanations Computer Organization and Architecture

2. I/O Organisation and Pipelining

2.1 (b)

One memory cycle is used to transfer data from I/O to memory when DMA is operating in cycle stealing mode.

3. Memory Organisation

3.1 (d)

Cache memory works on the principle of locality of reference. The principle of locality of reference states that “the references to memory at any given interval of time tends to be confined to within localized areas of memory”. In cache, by placing most frequently used data and instructions in a small cache the average access time can be minimized.

3.2 (b)

Effective memory access time

= Hit ratio × access time in cache memory + (1 – Hit ratio) × access time in main memory

= $0.95 \times 10 + (1 - 0.95) \times 100$

= $9.5 + 5 = 14.5$ ns

4. Data Representation and Programming

4.1 (b)

Immediate addressing:

Ex: MOV A, 10;

- Negative operands can used;
  MOV A, –10;
- When immediate operand changes, the program should be reassembled by changing data of instruction.
  MOV A, 10; ⇒ MOV A, 20;
- The program is easier to read when we use immediate addressing.
- The size of the operand is restricted by word length of the computer.

∴ Option (b) is correct.

4.2 (d)

Top down structured programming need not be used for developing programs.

Top down approach is readable and easy to prove.

4.4 (b)

A loader is a program which loads object code from secondary memory to main memory.

4.5 (a)

'do-while' statement is used less frequently compared to while. Most applications depend on the condition (test) at loop beginning, to execute the loop instead at the end of loop.

5. Data Structures

5.1 (d)

$A^B * C - D + E/(F/(G+H))$: Infix expression

$\Rightarrow \quad A \uparrow B * C - D + E/(F/(G+H))$

Convert it into prefix

$A \uparrow B * C - D + E/(F/+GH)$

$\Rightarrow \quad A \uparrow B * C - D + E//F + GH$

$\Rightarrow \quad \uparrow AB * C - D + E//F + GH$

$\Rightarrow \quad * \uparrow ABC - D + /E/F + GH$

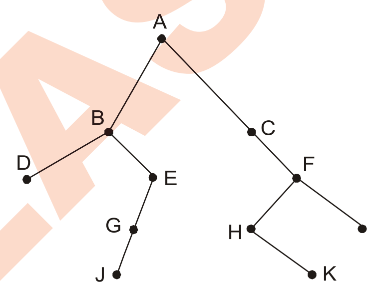
$\Rightarrow \quad - * \uparrow ABCD + /E/F + GH$

$\Rightarrow \quad + - * \uparrow ABCD /E/F + GH$

Note:

Order of precedence	Associativity
Parenthesis ( )	Left to right
Exponential ↑ or ^	Right to left
Multiplication or Division	Left to right
Addition or Substraction	Left to right

5.2 (c)



Post order traversal in a binary tree follows the order: Left-Right-Root (Recursively)

- First traverse the entire left subtree (recursively) and get the port order : DJGEB.
- Now traverse the entire right subtree (recursively) and get the post order : KHIFC
- At last add the root : A

∴ The order of nodes visited in post order form is DJGEBKHIFCA.

7. Miscellaneous

7.1 (b)

$= 5 \times 7 + (1 - 7) = 35 - 6 = 29$

■■■

5 Microprocessors and Microcontrollers

1. 8085 Microprocessors

1.1 Match **List-I** (Pre terminals) with **List-II** (Applications) and select the correct answer using the code given below the lists:

	List-I		List-II
A.	SID, SOD	1.	Wait state
B.	Ready	2.	Interrupt
C.	TRAP	3.	Serial data transfer
D.	ALE	4.	Memory or I/O read/ write
		5.	Address latch control

Codes:

	A	B	C	D
(a)	3	1	5	2
(b)	3	1	2	5
(c)	4	3	2	5
(d)	4	3	1	2

[ESE-1999]

2. 8086 Microprocessors

2.1 In 8086 microprocessor, if the code segment register contains 1FAB and IP register contains 10A1, the effective memory address is
(a) 20B51 (b) 304C
(c) FBC0 (d) FDB5

[ESE-1999]

2.2 To have the multiprocessing capabilities of the 8086 microprocessor, the pin connected to the ground is
(a) $\overline{DEN}$ (b) ALE
(c) INTR (d) $MN/\overline{MX}$

[ESE-1999]

■■■

Answers Microprocessors and Microcontrollers

1.1 (b) 2.1 (a) 2.2 (d)

Explanations Microprocessors and Microcontrollers

1. 8085 Microprocessors

1.1 (b)

A. SID - Serial input data
SOD - Serial output data } Serial data transfer
B. Ready - Wait state
C. TRAP - Hardware interrupt
D. ALE - Address latch enable control

2. 8086 Microprocessors

2.1 (a)

Effective memory address

= 1 FAB0 + 10A1 = 20 B51

2.2 (d)

To have the multiprocessing capabilities, 8086 microprocessor has to operate in the maximum mode which happens when pin $MN/\overline{MX}$ is low.

■■■

6 Analog and Digital Communication Systems

1. Analog Communication Systems

1.1 A 10 kW carrier is sinusoidally modulated by two carriers corresponding to a modulation index of 30% and 40% respectively. The total radiated power is
(a) 11.25 kW (b) 12.5 kW
(c) 15 kW (d) 17 kW [ESE-1999]

1.2 In phase modulation, the frequency deviation is
(a) independent of the modulating signal frequency
(b) inversely proportional to the modulating signal frequency
(c) directly proportional to the modulating signal frequency
(d) inversely proportional to the square root of the modulating frequency

[ESE-1999]

1.3 An arbitrary signal $m(t)$ has zero average value and it is band-limited to 3.2 kHz. It is sampled at the rate of 8 k samples/s. The samples are passed through an ideal band-pass filter with centre frequency of 32 kHz and bandwidth of 6.4 kHz. The output of the band-pass filter is
(a) AM-DSB signal with suppressed carrier
(b) AM-DSB signal with carrier
(c) AM-SSB signal with carrier
(d) a sequence of exponentially decaying sine waves

[ESE-1999]

1.4 The correct sequence of subsystems in an FM receiver is
(a) mixer, RF amplifier, limiter, IF amplifier, discriminator, audio amplifier
(b) RF amplifier, mixer, IF amplifier, limiter, discriminator audio amplifier
(c) RF amplifier, mixer, limiter, discriminator, IF amplifier, audio amplifier
(d) mixer, IF amplifier, limiter, audio amplifier, discriminator

[ESE-1999]

1.5 In a superheterodyne receiver, the IF is 455 kHz, if it is tuned to 1200 kHz, the image frequency will be
(a) 1655 kHz (b) 745 kHz
(c) 2110 kHz (d) 910 kHz

[ESE-1999]

1.6 **Assertion (A):** Square law detectors are not particular satisfactory for the detection of modulated signals.
Reason (R): With square law detectors, harmonic distortion of as high as 25% occurs for a completely modulated signal.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true [ESE-1999]

1.7 The signal $(1 + M\cos 4\pi t)\cos(2\pi \times 10^3\, t)$ contains the frequency component (in Hz)
(a) 998, 1000 and 1002
(b) 1000 and 2000
(c) dc, 2 and 1000
(d) ..., 996, 998, 1000, 1002, 1004, ...

[ESE-1999]

2. Random Variables, Random Process & Noise

2.1 Consider a random sinusoidal signal $x(t) = \sin(\omega_0 t + \phi)$ where a random variable 'ϕ' is uniformly distributed in the range $\pm\pi/2$. The mean value of $x(t)$ is
(a) zero (b) $(2/\pi)\sin(\omega_0 t)$
(c) $2/\pi \cos(\omega_0 t)$ (d) $2/\pi$

[ESE-1999]

2.2 A system has a receiver noise resistance of 50 Ω. It is connected to an antenna with an input resistance of 50 Ω. The noise figure of the system is

(a) 1 (b) 2
(c) 50 (d) 101

[ESE-1999]

3. Digital Communication Systems

3.1 Consider the following statements comparing delta modulation with PCM systems: DM requires

1. a lower sampling rate
2. a higher sampling rate
3. a large bandwidth
4. simpler hardware

Which of these statements are correct?

(a) 1, 2 and 4 (b) 1, 2, and 3
(c) 1, 3 and 4 (d) 2 and 4

[ESE-1999]

3.2 12 signals each band-limited to 5 kHz are to be transmitted over a single channel by frequency division multiplexing. If AM-SSB modulation guard band of 1 kHz is used, then the bandwidth of the multiplexed signal will be

(a) 51 kHz (b) 61 kHz
(c) 71 kHz (d) 81 kHz

[ESE-1999]

4. Information Theory

4.1 A source deliver symbols X_1, X_2, X_3 and X_4 with probabilities 1/2, 1/4, 1/8 and 1/8 respectively. The entropy of the system is

(a) 1.75 bits per second
(b) 1.75 bits per symbol
(c) 1.75 symbols per second
(d) 1.75 symbols per bit

[ESE-1999]

■■■

Answers Analog and Digital Communication Systems

1.1	(a)	1.2	(c)	1.3	(a)	1.4	(b)	1.5	(c)	1.6	(a)	1.7	(a)	2.1	(b)	2.2	(b)
3.1	(d)	3.2	(c)	4.1	(b)												

Explanations Analog and Digital Communication Systems

1. Analog Communication Systems

1.1 (a)

$$m^2 = m_1^2 + m_2^2$$

$$\Rightarrow \quad m^2 = (0.3)^2 + (0.4)^2$$

$$\Rightarrow \quad m^2 = 0.25$$

$$\Rightarrow \quad m = 0.5$$

Total Radiated Power,

$$P_T = P_c\left(1+\frac{m^2}{2}\right) = 10\left(1+\frac{0.25}{2}\right) = 11.25 \text{ kW}$$

1.2 (c)

Let modulating signal, $m(t) = v_m \sin \omega_m t$

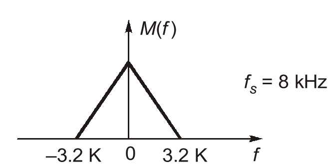
In PM, $\theta_i = \omega_c t = k_p\, m(t)$

$$\Rightarrow \quad \omega_i = \frac{d\theta_i}{dt} = \omega_c + k_p\, \dot{m}(t)$$

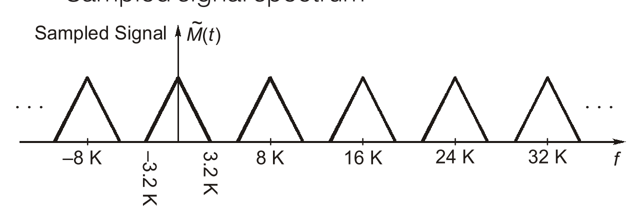
$$\Rightarrow \quad \omega_i = \omega_c + k_p\, \omega_m\, v_m \cos \omega_m\, t$$

This frequency deviation is $k_p \omega_m v_m \cos\omega_m t$ which is directly proportional to ω_m.

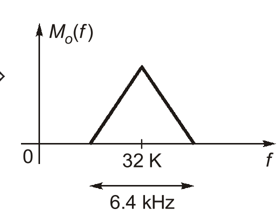
1.3 (a)



Sampled signal spectrum

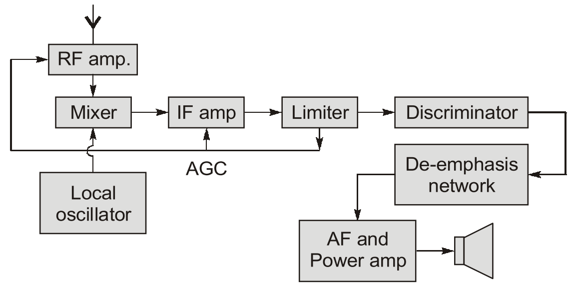


Filter output ⇒



This is DSB-SC signal.

1.4 (b)



FM Receiver Block diagram

1.5 (c)

$$f_{si} = f_s + 2f_i = 1200 + 2 \times 455 = 2110 \text{ kHz}$$

1.7 (a)

$(1 + M\cos 4\pi t)\cos(2\pi \times 10^3\, t)$

$\Rightarrow \cos(2\pi \times 10^3\, t) + M\cos 4\pi t \cos(2\pi \times 10^3\, t)$

$\Rightarrow \cos(2\pi \times 10^3\, t) + M/2\{\cos 2\pi(1000 + 2)t + \cos 2\pi(1000 - 2)t\}$

$\Rightarrow$ Thus the signal contains frequency components of 998, 1000 and 1002 Hz.

2. Random Variables, Random Process & Noise

2.1 (b)

$$\overline{x(t)} = \overline{\sin(\omega_0 t + \phi)}$$

$$= \int_{-\infty}^{\infty} \sin(\omega_0 t + \phi)\rho_\phi(\phi)d\phi$$

$$= \frac{1}{\pi}\int_{-\pi/2}^{\pi/2} \sin(\omega_0 t + \phi)d\phi$$

$$= \frac{1}{\pi}\left[-\cos(\omega_0 t + \phi)\Big|_{-\pi/2}^{\pi/2}\right]$$

$$= \frac{1}{\pi}\left[-\cos\left(\omega_0 t + \frac{\pi}{2}\right) + \cos\left(\omega_0 t - \frac{\pi}{2}\right)\right]$$

$$= \frac{1}{\pi}[\sin\omega_0 t + \sin\omega_0 t] = \frac{2\sin\omega_0 t}{\pi}$$

2.2 (b)

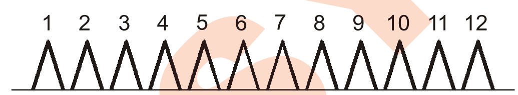
$R_{eq} \rightarrow$ Receiver noise resistance

$R_a \rightarrow$ Resistance of antenna

$$F = 1 + \frac{R_{eq}}{R_a} = 1 + \frac{50}{50} = 1 + 1 = 2$$

3. Digital Communication Systems

3.2 (c)



$$\text{BW} = 12 \times 5 + (12 - 1) \times 1$$
$$= 60 + 11 = 71 \text{ kHz}$$

4. Information Theory

4.1 (b)

$$H(x) = \sum_{i=1}^{4} P(i)\log_2 \frac{1}{P(i)}$$

$$= \frac{1}{2}\log_2 2 + \frac{1}{4}\log_2 4 + \frac{1}{8}\log_2 8 + \frac{1}{8}\log_2 8$$

$$= 1.75 \text{ bits per symbol}$$

■■■

7 Advanced Communication Topics

2. Microwave and Satellite Communication Systems

2.1 13 dBm is equivalent to

(a) 2 mW (b) 20 W

(c) 20 mW (d) 2 MW

[ESE-1999]

2.2 **Assertion (A):** Modern long-distance communication is carried out via satellite.

Reason (R): It covers the entire globe without appreciable fading of signals.

(a) Both A and R are true and R is the correct explanation of A

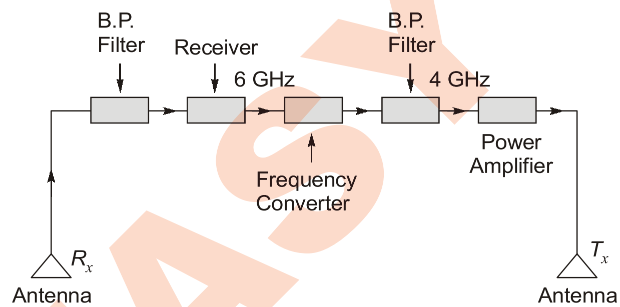
(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

[ESE-1999]

2.3 The system shown in the given figure is



(a) an LOS link

(b) a satellite transponder

(c) a low noise amplifier

(d) a frequency divider

[ESE-1999]

3. Fibre Optic Communication Systems

3.1 A glass fibre has refractive indices n_1 of 1.5 and n_2 of 1. Assuming $c = 3 \times 10^8$ m/s the multipath time dispersion will be

(a) 2.5 ns/m (b) 2.5 μs/m

(c) 5 ns/m (d) 5 μs/m

[ESE-1999]

■■■

Answers Advanced Communication Topics

2.1 (c) 2.2 (a) 2.3 (b) 3.1 (a)

Explanations Advanced Communication Topics

2. Microwave and Satellite Communication Systems

2.1 (c)

$$13 = 10 \log\left(\frac{P}{10^{-3}}\right)$$

$$\Rightarrow \quad \frac{P}{10^{-3}} = (10)^{1.3} = 20$$

$$\Rightarrow \quad P = 20 \text{ mW}$$

3. Fibre Optic Communication Systems

3.1 (a)

We know that,

Multipath time dispersion (MTD)

$$= \frac{\Delta t}{z} = \frac{n_1}{n_2} \cdot \frac{\Delta n}{c} \quad \text{given, } n_1 = 1.5,\ n_2 = 1$$

$$\therefore \quad \Delta n = (1.5 - 1.0) = 0.5$$

and $c = 3 \times 10^8$ m/sec

$$\therefore \quad \text{M.T.D.} = \frac{1.5}{1.0} \times \frac{0.5}{(3 \times 10^8)} \text{ m/sec}$$

$$= 2.5 \times 10^{-9} = 2.5 \text{ ns/m}$$

$$\approx 2.5\ \mu\text{ sec/km}$$

■■■

8 Advanced Electronics Topics

1. VLSI Technology

1.1 In an integrated circuit, the SiO_2 layer provides
(a) electrical connection to external circuit
(b) physical strength
(c) isolation
(d) conducting path [ESE-1999]

■■■

Answers Advanced Electronics Topics

1.1 (c)

Explanations Advanced Electronics Topics

1. VLSI Technology

1.1 (c)

SiO_2 has the fundamental property of preventing the diffusion of impurities through it.

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