DETAILED SOLUTIONS

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ESE 2026 : Prelims Exam
CLASSROOM TEST SERIES

E & T ENGINEERING

Test 18

Full Syllabus Test 2 : Paper-II

1.	(a)	26.	(d)	51.	(b)	76.	(a)	101.	(d)	126.	(d)
2.	(d)	27.	(a)	52.	(a)	77.	(b)	102.	(d)	127.	(d)
3.	(a)	28.	(d)	53.	(d)	78.	(a)	103.	(a)	128.	(d)
4.	(c)	29.	(c)	54.	(c)	79.	(b)	104.	(d)	129.	(d)
5.	(c)	30.	(c)	55.	(a)	80.	(c)	105.	(d)	130.	(b)
6.	(c)	31.	(b)	56.	(c)	81.	(c)	106.	(b)	131.	(c)
7.	(d)	32.	(b)	57.	(a)	82.	(b)	107.	(d)	132.	(d)
8.	(a)	33.	(c)	58.	(d)	83.	(a)	108.	(a)	133.	(b)
9.	(c)	34.	(c)	59.	(d)	84.	(b)	109.	(b)	134.	(d)
10.	(d)	35.	(d)	60.	(b)	85.	(d)	110.	(c)	135.	(c)
11.	(b)	36.	(d)	61.	(a)	86.	(c)	111.	(a)	136.	(b)
12.	(c)	37.	(b)	62.	(a)	87.	(a)	112.	(a)	137.	(a)
13.	(d)	38.	(d)	63.	(c)	88.	(b)	113.	(c)	138.	(c)
14.	(a)	39.	(d)	64.	(b)	89.	(b)	114.	(c)	139.	(d)
15.	(c)	40.	(c)	65.	(b)	90.	(c)	115.	(a)	140.	(a)
16.	(d)	41.	(c)	66.	(d)	91.	(c)	116.	(b)	141.	(c)
17.	(c)	42.	(d)	67.	(c)	92.	(c)	117.	(d)	142.	(c)
18.	(d)	43.	(b)	68.	(d)	93.	(c)	118.	(c)	143.	(b)
19.	(c)	44.	(b)	69.	(b)	94.	(d)	119.	(d)	144.	(c)
20.	(b)	45.	(d)	70.	(c)	95.	(b)	120.	(b)	145.	(c)
21.	(c)	46.	(a)	71.	(d)	96.	(b)	121.	(d)	146.	(b)
22.	(d)	47.	(d)	72.	(c)	97.	(c)	122.	(b)	147.	(a)
23.	(b)	48.	(c)	73.	(c)	98.	(a)	123.	(b)	148.	(a)
24.	(d)	49.	(d)	74.	(b)	99.	(b)	124.	(a)	149.	(c)
25.	(c)	50.	(c)	75.	(d)	100.	(c)	125.	(a)	150.	(a)

DETAILED EXPLANATIONS

1. **(a)**

2. **(d)**

Given:

$L = 10\ \mu H/m = 10^{-5}$ H/m

$C = 40$ pF/m $= 4 \times 10^{-11}$ F/m

Electrical path length is 'βl'

where,
$$\beta = \omega\sqrt{LC}$$
$$= 2\pi \times 10^6 \times 30\sqrt{4\times10^{-16}}$$
$$\beta = 1.2\pi \text{ rad/m}$$

$\therefore$
$$\beta l = 1.2\pi \times 0.5 \qquad (\because l = 50 \text{ cm} = 0.5 \text{ m})$$
$$= 0.6\pi \text{ rad} \quad \text{(or)} \quad 108^\circ$$

3. **(a)**

Hydroelectric power stations are generally located in hilly areas where dams can be built conveniently and large water reservoirs can be obtained.

4. **(c)**

At $t = 0$:
$$v(0) = v(0^+) = V_o = 0$$

Now,
$$i_c(0^+) = -(-12.25) = 12.25 \text{ mA}$$

Thus,
$$\frac{dv}{dt} = \frac{i_c(0^+)}{C} = \frac{12.25\times10^{-3}}{0.125\times10^{-6}} = 98 \text{ kV/s}$$

Therefore, the value of the initial rate of change of voltage across the capacitor is 98 kV/s.

5. **(c)**

Given, $g(t) \xleftrightarrow{F.T} G(\omega) = \dfrac{\omega^2+21}{\omega^2+9}$

From the inverse Fourier transform,
$$g(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} G(\omega)e^{j\omega t}d\omega$$

put $t = 0$,
$$g(0) = \frac{1}{2\pi}\int_{-\infty}^{\infty} G(\omega)d\omega$$

$\therefore$
$$\int_{-\infty}^{\infty} G(\omega)d\omega = 2\pi g(0)$$

From
$$G(\omega) = \frac{\omega^2+21}{\omega^2+9} = \frac{\omega^2+9}{\omega^2+9} + \frac{12}{\omega^2+9} = 1 + \frac{2(2)(3)}{\omega^2+3^2}$$

Taking inverse Fourier transform,

$$g(t) = \delta(t) + 2e^{-3|t|} \qquad \left[\because e^{-a|t|} \xleftrightarrow{F.T} \frac{2a}{a^2+\omega^2}\right]$$

$$g(0) = \delta(0) + 2e^{-0} = 1 + 2 = 3$$

$$\therefore \quad \int_{-\infty}^{\infty} G(\omega)d\omega = 3 \times 2\pi = 6\pi$$

6. (c)

When magnetic materials are magnetized, changes in their dimensions are generally observed. This property of the material is known as magnetostriction.

7. (d)

Given: $$\eta = 0.75\eta_0 = \frac{3}{4}\eta_0 = \frac{3}{4}\times 120\pi = 90\pi$$

$$\mu_r = 1$$

$$\therefore \quad 90\pi = \frac{120\pi\times\sqrt{\mu_r}}{\sqrt{\epsilon_r}}$$

$$90\pi = \frac{120\pi\times\sqrt{1}}{\sqrt{\epsilon_r}}$$

$$\therefore \quad \sqrt{\epsilon_r} = \frac{4}{3} \quad \Rightarrow \quad \epsilon_r = \frac{16}{9} = 1.77$$

8. (a)

Given: $$N_r = 1200 \text{ rpm at } T_{max}$$

$$N_s = \frac{120f}{P} = \frac{120\times 50}{4} = 1500 \text{ rpm}$$

Slip at maximum torque:

$$s_{T_{max}} = \frac{1500-1200}{1500} = 0.2$$

$$\frac{T_{st}}{T_{max}} = \frac{2s_{T_{max}}}{s_{T_{max}}^2+1} \qquad \{s_{st} = 1\}$$

$$= \frac{2\times 0.2}{1+(0.2)^2} = \frac{0.4}{1.04} = 0.385$$

9. (c)

$$\frac{di(0^+)}{dt} = \frac{V_o}{L} = \frac{100}{100}\times 10^3 = 1000 \text{ A/s}$$

10. (d)

From Maxwell's inductance-Capacitance bridge,

$$R_1 = \frac{R_2 R_3}{R_4} = \frac{300 \times 700}{1500} = 140\ \Omega$$

$$L_1 = R_2 R_3 C_4 = 700 \times 1500 \times 0.8 \times 10^{-6} = 0.84\ \text{H}$$

$$\text{Q-factor, } Q = \frac{\omega L_1}{R_1} = \frac{2\pi \times 1100 \times 0.84}{140} = 41.46$$

11. (b)

Given: Inner radius of spherical capacitor,

$$r_a = 9\ \text{cm}$$

Outer radius of spherical capacitor,

$$r_b = 10\ \text{cm}$$

Capacitance of the spherical capacitor:

$$C = \frac{4\pi \epsilon_0 \epsilon_r\, r_a r_b}{(r_b - r_a)}$$

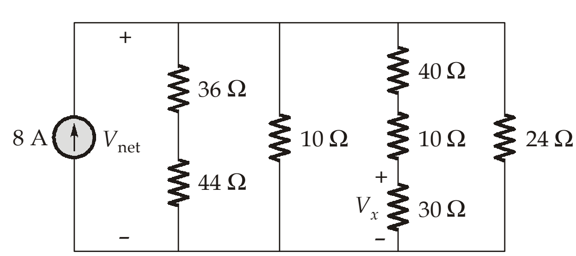
$$\therefore \quad C = \frac{0.09 \times 0.1 \times 3}{9 \times 10^9 (0.1 - 0.09)}$$

$$C = 300\ \text{pF}$$

12. (c)

- An induction motor is a singly excited machine, as only the stator winding is energized from an AC source. The working of an induction motor is similar to that transformer.
- Squirrel-cage induction motors require less conductor material than slip-ring motors; hence, copper losses in squirrel cage motors are lower, which results in higher efficiency. Further, the rotor bars are permanently short-circuited, and it is not possible to add external resistance to the rotor circuit to obtain high starting torque. Hence, it is preferred for low starting torque and high efficiency.
- When the stator and rotor slots are equal in number or have an integral ratio, strong alignment forces are produced between the stator and rotor at the instant of starting. They align in such a way that both face each other, resulting in minimum reluctance of the magnetic path, and the motor refuses to start. This phenomenon of magnetic locking between the stator and rotor teeth of an induction motor at the time of starting is known as cogging or teeth locking.

13. (d)



The voltage across the 8 A current source is equal to

$$V_{net} = (8\ \text{A})R_{eq}$$

where, $$R_{eq} = 80\,\Omega \,\|\, 10\,\Omega \,\|\, 24\,\Omega \,\|\, (80\,\Omega) = 6\,\Omega$$

∴ $$V_{net} = 8 \times 6 = 48\ \text{V}$$

∴ $$V_x = 48 \times \left(\frac{30}{80}\right) = 18\ \text{V}$$

14. (a)

Let $h(t)$ be the impulse response of the system,

$$y(t) = u(t) * h(t)$$

$$= \int_0^t u(\tau)h(t-\tau)d\tau$$

$$= \int_0^t (2+t-\tau)e^{-3(t-\tau)}u(\tau)d\tau$$

$$h(t) = (t+2)e^{-3t}u(t);\ t > 0$$

(or) $$h(t) = te^{-3t}u(t) + 2e^{-3t}u(t)$$

∴ Transfer function: $$H(s) = \frac{Y(s)}{X(s)}$$

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

$$= \frac{1+2(s+3)}{(s+3)^2} = \frac{2s+7}{(s+3)^2}$$

15. (c)

Given, $$85.5\ \text{MHz} < f_c < 105\ \text{MHz}$$

$$f_{L0} - f_c = 10.8\ \text{MHz}$$

$$f_{L0} = 10.8\ \text{MHz} + f_c$$

$$f_{L0\ min} = 10.8 + 85.5 = 96.3\ \text{MHz}$$

$$f_{L0\ max} = 10.8 + 105 = 115.8\ \text{MHz}$$

∴ Range of tuning of local oscillator = 96.3 MHz - 115.8 MHz

16. (d)

Given, $$x(n) = a^n u[n]$$

By taking the z-transform,

$$X(z) = \frac{1}{1-az^{-1}}$$

Given, $$g(n) = x[n] + ax[n-1]$$

$$G(z) = X(z) + az^{-1}X(z)$$

$$= X(z)[1 + az^{-1}]$$

$\therefore \quad G(z) = \dfrac{1+az^{-1}}{1-az^{-1}}$

$= \dfrac{1}{1-az^{-1}} + \dfrac{az^{-1}}{1-az^{-1}}$

Taking the inverse z-transform,

$g(n) = a^n u[n] + a \cdot a^{n-1} u[n-1]$

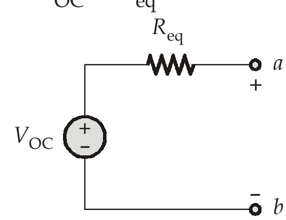
$g(n) = a^n u[n] + a^n u[n-1]$

At $n = 1$, $\quad g(1) = a + a = 2a$

17. (c)

Since the circuit is linear, we have:

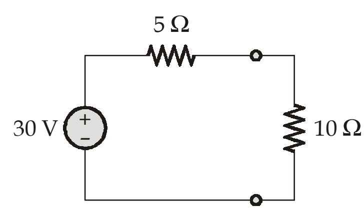
$v = V_{OC} + R_{eq}\, i$



$\therefore \quad V_{OC} = 30 \text{ V}$

and $\quad R_{eq} = \dfrac{15}{3} = 5\,\Omega$

The equivalent circuit is therefore a 30 V source in series with a 5 Ω resistor supplying a 10 Ω load.



Hence, the power delivered to the 10 Ω resistor is:

$\therefore \quad \text{Power} = \left(\dfrac{30}{15}\right)^2 \times 10 = (2)^2 \times 10 = 40 \text{ W}$

18. (d)

Pole pitch = slots/poles

$= \dfrac{36}{4} = 9$

Coil span = 1 to 8

= 7

Hence, the coil is short-pitched by 2 slots.

$\text{Slot angle} = \dfrac{180^\circ}{\text{Pole pitch}}$

$= \dfrac{180^\circ}{9} = 20^\circ$

$$\text{Short-pitch angle, } \alpha = 2 \times 20° = 40°$$

$$\text{Pitch factor, } k_{pn} = \cos\frac{n\alpha}{2}$$

For the fundamental pitch factor: $n = 1$

$$k_p = \cos\frac{40°}{2}$$

$$k_p = \cos 20°$$

19. (c)

Given: Two point charges,

$$q_1 = -10 \text{ nC}$$
$$q_2 = +10 \text{ nC}$$

$$\text{Energy stored, } E = \frac{q_1 q_2}{4\pi\epsilon_0 r}$$

$$= \frac{-10\times10^{-9}\times10\times10^{-9}}{4\pi\times\frac{10^{-9}}{36\pi}\times\sqrt{(6)^2+0+0}}$$

$$E = -150 \text{ nJ}$$

20. (b)

We know that, to achieve single-mode operation, the V-number of the fiber should satisfy: $0 \le V \le 2.405$

At cutoff, $V = 2.405$ at $\lambda = \lambda_c$

$$\lambda_c = \frac{2\pi}{2.405}a(\text{N.A})$$

where a = core radius = 40 μm

$$\text{NA (Numerical aperture)} = \sqrt{n_1^2 - n_2^2}$$

$$= n_1\sqrt{1-\left(\frac{n_2}{n_1}\right)^2}$$

$$= 1.5\sqrt{1-(0.8)^2} = 1.5 \times 0.6 = 0.9$$

$$\lambda_c = \frac{2\pi}{2.405}\times40\times0.9\times10^{-6}\text{m}$$

For simplification $2.405 \approx 2.4$

$$\lambda_c = \frac{2\pi}{2.4}\times40\times0.9\times10^{-6}$$

$$\lambda_c = 30\pi\ \mu\text{m}$$

For any wavelength $\lambda < \lambda_c = 30$ μm, multimode propagation will exist. Hence, option (b) is correct.

21. (c)

- 8257 is a 4-channel programmable DMA controller. Each channel incorporates two 16-bit registers, namely the DMA address register and the byte count register. These registers are initialized before a channel is enabled.
- In the 8259 A programmable interrupt controller, all eight interrupt vectors can be spaced or prioritized at an intervals of 4-bit or 8-bit locations but it can be 16-bit also if additional 8259A controllers are cascaded.
- 8255 is a widely used programmable parallel I/O device. It can be programmed to transfer data under various conditions from I/O devices using the interrupt-driven I/O method.

22. (d)

$$n_{no} = N_D; \quad P_{no} = \frac{n_i^2}{N_D}$$

$$n_{po} = \frac{n_i^2}{N_A}; \quad P_{po} = N_A$$

23. (b)

- In Fleming's right hand rule, if thumb is pointing towards the conductor's motion and the forefinger pointing towards the magnetic field direction, the middle finger gives the direction of the induced current or induced emf.
- The Permeance in magnetic circuit resembles the conductance in electric circuit.

24. (d)

For a moving-iron instrument at equilibrium,

$$K\theta = \frac{1}{2}I^2\frac{dM}{d\theta} \quad \text{(or)} \quad \frac{1}{2}I^2\frac{dL}{d\theta}$$

$$(25 \times 10^{-6}) \times \theta = \frac{1}{2}\times(5)^2\times\frac{d}{d\theta}\left[10+3\theta-\frac{\theta^2}{4}\right]\times10^{-6}$$

$$(25 \times 10^{-6}) \times \theta = \frac{1}{2}\times25\times\left[3-\frac{\theta}{2}\right]\times10^{-6}$$

$$2\theta = 3-\frac{\theta}{2}$$

$$\therefore \quad \theta = 1.2 \text{ rad}$$

25. (c)

Speed of the vehicle = 60 km/hr

Radius of the cell, (R) = 3 km

Diameter of the cell, D = 6 km

The time period between handoffs is the time taken by the vehicle to move from one cell to the next.

$$t = \frac{D}{V} = \frac{6}{60} = \frac{1}{10} \text{ hour}$$

$$\frac{1}{10}\text{hr} = 6 \text{ min} = 360 \text{ seconds}$$

Hence, option (c) is correct.

26. (d)

The 8259A PIC can manage 8 levels of interrupts. If more interrupt levels are required, the 8259A is used in cascade mode. In cascade mode, one master 8259A along with eight slave 8259As can handle upto 64 interrupts.

27. (a)

$$A = \frac{Z_{22}}{Z_{12}} = \frac{6}{2} = 3, \; B = \frac{\Delta Z}{Z_{21}} = \frac{32}{2} = 16$$

$$C = \frac{1}{Z_{21}} = \frac{1}{2} = 0.5, \; D = \frac{Z_{22}}{Z_{21}} = \frac{6}{2} = 3$$

$\therefore \quad AD - BC = (3)\,(3) - (16)\,(0.5) = 1$

Alternate:

As $Z_{21} = Z_{12}$ it implies circuit is reciprocal then it must be reciprocal in any parameter.
Hence, $AD - BC$ must be 1.

28. (d)

(a)

$$y(t) = t^2 x(t)$$
$$y_1(t) = t^2 x(t - t_o)$$
$$y_2(t) = (t - t_o)^2\, x(t - t_o)$$
$$y_1(t) \neq y_2(t)$$

$\therefore$ The system is time-variant

(b)

$$y_1(t) = \sin 10\pi t\, x(t - t_o)$$
$$y_2(t) = x(t - t_o)\, \sin 10\pi(t - t_o)$$
$$y_1(t) \neq y_2(t) \quad \Rightarrow \text{System is time-variant}$$

(c)

$$y_1(t) = x(-2t - t_o)$$
$$y_2(t) = x[-2\,(t - t_o)]$$
$$y_1(t) \neq y_2(t) \quad \Rightarrow \text{System is time-variant}$$

(d)

$$y_1(t) = e^{3x(t - t_0)}$$
$$y_1(t) = y_2(t) \quad \Rightarrow \text{System is time-invariant}$$

29. (c)

From the figure, it is clear that

$$f_1 = 0.25 \text{ MHz}$$
$$f_3 = 0.75 \text{ MHz}$$

We know, Roll-off factor $(\alpha) = \dfrac{f_3 - f_1}{f_3 + f_1} = \dfrac{0.75 - 0.25}{0.75 + 0.25}$

$$\alpha = 0.5$$

30. (c)

- SCTP is a new transport layer protocol designed to combine some features of UDP and TCP. SCTP provides reliability similar to TCP but maintains a separation between data transmissions (called "chunks"), similar to datagrams in UDP.
- SCTP provides flow control, error control, and congestion control.

31. (b)

$$s = \frac{N_s - N_r}{N_s}$$

$$\frac{2}{100} = \frac{N_s - 980}{N_s}$$

$$100N_s - 98000 = 2N_s$$

$$98N_s = 98000$$

$$N_s = 1000 \text{ rpm}$$

$$N_s = \frac{120f}{P}$$

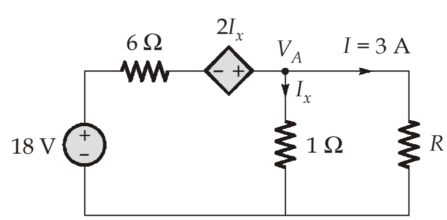
$$\Rightarrow \quad f = \frac{N_s \times P}{120} = \frac{1000 \times 6}{120} = 50 \text{ Hz}$$

$$\text{Electrical angle} = 2\pi f = 2\pi(50)$$

$$= 100\pi \text{ radian}$$

$$100\pi \text{ radian} = 18000 \text{ degree} = 0 \text{ degree}$$

32. (b)



Applying KCL at node V_A, we get:

$$\frac{V_A - 2I_x - 18}{6} + I_x + 3 = 0$$

and $\quad V_A = I_x$

Thus, $\quad \frac{I_x - 2I_x - 18}{6} + I_x = -3$

$$\frac{5}{6} I_x = 0$$

$$I_x = 0$$

Therefore, $\quad V_A = 0$

$\therefore \quad R = 0 \ \Omega$

33. (c)

By the definition of DTFS,

$$x(t) = \sum_{k=\infty}^{\infty} X(k)e^{j2\pi kt}$$

$$\therefore \quad x(t) = je^{j2\pi t} - je^{-j2\pi t} + e^{j6\pi t} + e^{-j6\pi t}$$

$$= j\left[e^{j2\pi t} - e^{-j2\pi t}\right] + \left[e^{j6\pi t} + e^{-j6\pi t}\right]$$

$$= (2j)(j)\left[\frac{e^{j2\pi t} - e^{-j2\pi t}}{2j}\right] + \frac{2\left[e^{j6\pi t} + e^{-j6\pi t}\right]}{2}$$

$$= -2\sin 2\pi t + 2\cos 6\pi t$$

$$= -2[\sin 2\pi t - \cos 6\pi t]$$

34. (c)

The FM signal can be expressed as

$$s(t) = A_c \sum_{n=-\infty}^{\infty} J_n(\beta)\cos\left[2\pi(f_c + nf_m)t\right]$$

- The FM signal consists of infinite sidebands, whose amplitudes vary as $A_c J_n(\beta)$. Hence, the amplitude of any sideband depends on the modulation index, β.
- The amplitude of the carrier frequency, f_c is obtained by substituting $n = 0$, which gives $A_c J_0(\beta)$. Hence, the carrier frequency can disappear when $J_0(\beta) = 0$.

35. (d)

Electrical conductivity (σ) is a fundamental material parameter, an intrinsic property quantifying a substance's ability to conduct electric current.

36. (d)

We know that,

$$\text{Antenna beam width} = \frac{\text{Beam duration}}{\text{Rotation period}} \times 360°$$

$$= \frac{150 \times 10^{-3}}{10} \times 360° = 5.4°$$

37. (b)

Given: $\dfrac{\text{Pole arc}}{\text{Pole pitch}} = 0.75$

$Z = 800$

$A = 2$ and $P = 10$

The number of conductors in the compensating winding per pole is:

$$Z_{CW} = \frac{Z}{AP}\left(\frac{\text{Pole arc}}{\text{Pole pitch}}\right)$$

$$Z_{CW} = \frac{800}{2\times 10}\times(0.75) = 30$$

38. (d)

$$P = |S|\cos\theta$$

$$Q = |S|\sin\theta$$

$\therefore$ $\cos\theta = 0.8$ and $\sin\theta = 0.6$

$\therefore$ $$|S| = \frac{P}{\cos\theta} = \frac{8}{0.8} = 10\text{ kVA}$$

$$Q = 10\sin\theta = 10 \times 0.6 = 6\text{ kVAR}$$

$\therefore$ $$S = (8 + j6)\text{ kVA}$$

39. (d)

In a dual-slope integrating digital voltmeter,

$$\left(\frac{t_1}{t_2}\right)V_{\text{in}} = V_{\text{ref}}$$

where, t_1 is the first integration time.

$$t_1 = 10\times\frac{1}{50} = 0.2\text{ s}$$

Given, $V_{\text{in}} = 1$ V and $V_{\text{ref}} = 2$ V

$\therefore$ $$t_2 = \frac{V_{\text{in}}}{V_{\text{ref}}}t_1 = \frac{1}{2}\times 0.2 = 0.1\text{ s}$$

Total conversion time, $t = t_1 + t_2 = 0.2 + 0.1 = 0.3s$

40. (c)

Key characteristics of 2D-materials:

- Very large surface-to-volume ratio.
- Strong in-plane properties (electrical, thermal).
- Exhibit unique band gap behavior in monolayers.

41. (c)

Given: $d = 20$ m

$P_t = 50$ W,

$f = 900$ MHz

Gain of half-wave dipole = 1.64

$\therefore$ $G_t = G_r = 1.64$

$$\lambda = \frac{c}{f} = \frac{3\times 10^8}{9\times 10^8} = \frac{1}{3}\text{m}$$

$$\therefore \quad \text{Power received, } P_r = \frac{P_t G_t G_r}{\left(\frac{4\pi d}{\lambda}\right)^2}$$

$$= \frac{50 \times 1.64 \times 1.64}{\left(\frac{4\pi \times 20}{\frac{1}{3}}\right)^2} = 236.5\ \mu\text{W}$$

42. (d)

- In a star connection, $I_L = I_{ph}$ and $V_L = \sqrt{3}\,V_{ph}$, whereas in a delta connection, $V_L = V_{ph}$ and $I_L = \sqrt{3} I_{ph}$.
- The order in which the voltages in the three phases reach their maximum positive values is called the phase sequence or phase order. This is determined by the direction of rotation of the alternator. For a three-phase system, there are only two possible phase sequences: 1-2-3 and 3-2-1, corresponding to the two possible directions of alternator rotation.

43. (b)

Addition of pole, it implies addition of Integral controller:

- It improves steady state output.
- Increase rise time.
- Disturb transient response.

44. (b)

Corrosion can be eliminated in a resistance thermometer by enclosing the elements in a protective tubular glass made of pyrex, quartz or crystal, depending upon the temperature range.

45. (d)

We know that,

$$\frac{1}{\tau} = \frac{1}{\tau_r} + \frac{1}{\tau_{nr}}$$

$$= \frac{1}{100\text{ nsec}} + \frac{1}{200\text{ nsec}}$$

$$= (0.01 + 0.005) \times 10^9$$

$$\Rightarrow \quad \frac{1}{\tau} = 0.015 \times 10^9$$

$$\therefore \quad \text{The effective lifetime, } \tau = \frac{10^{-9}}{0.015} \quad \text{(or)} \quad 66.67 \times 10^{-9}\text{ s}$$

$$\Rightarrow \quad \tau = 66.67\text{ ns}$$

46. (a)

For circular,

Cutoff frequency expressions

- For TE Mode: $f_c = \dfrac{1.841c}{2\pi a}$
- For TM Mode: $f_c = \dfrac{2.405c}{2\pi a}$

  where
  - a = radius of circular waveguide
  - c = speed of light

And $\lambda \propto \dfrac{1}{f}$

47. (d)

From the given capacitance versus voltage characteristic curve:

Flat band voltage, $V_{FB} = -1$ V

Threshold voltage, $V_T = 1$ V

We know that

Flat band voltage, $V_{FB} = -(\phi_{n^+} - \phi_{body})$

$\therefore$ $-1 = -(0.55 - \phi_{body})$

$\therefore$ $\phi_{body} = -0.45$ V

48. (c)

The number of zeros at infinity is

$$P - Z \text{ if } P > Z$$

From the given transfer function,

$$P = 4, \quad Z = 1$$

$\therefore$ $P - Z = 4 - 1 = 3$

49. (d)

Given: $V_0 = 100$ V,

$g = 0.05$ V-m

$t = 1 \text{ mm} = 1 \times 10^{-3}$ m

Area, $A = 1 \text{ mm} \times 1 \text{ mm} = 10^{-6}$ m^2

Force, $F = P.A$

Pressure, $P = \dfrac{V_0}{g \cdot t}$

$$= \frac{100}{0.05 \times 10^{-3}} = 2 \times 10^{6} \text{ N/m}^2$$

$\therefore$ Force, $F = 2 \times 10^6 \times 1 \times 10^{-6}$

$\therefore$ $F = 2$ N

50. (c)

Given: Lattice parameter, $a = 4$ Å

$$d_{(211)} = \frac{a}{\sqrt{h^2+k^2+1^2}}$$

$$= \frac{4}{\sqrt{2^2+1^2+1^2}} = \frac{4}{\sqrt{6}}$$

$$d_{(211)} = 1.63 \text{ Å}$$

51. (b)

For a half-wave dipole, the magnetic field is given by:

$$H = \frac{I_m}{2\pi r}\left[\frac{\cos\left(\frac{\pi}{2}\cos\theta\right)}{\sin\theta}\right]$$

$$10 \times 10^{-6} = \frac{I_m}{2\pi \times 2 \times 10^3}\left[\frac{\cos\left[\frac{\pi}{2}\cos\left(\frac{\pi}{2}\right)\right]}{\sin\left(\frac{\pi}{2}\right)}\right]$$

$\therefore$ $$I_m = 0.125 \text{ A}$$

Average power radiated, $P_{avg} = I_{rms}^2 * R_r$

$$= \left(\frac{I_m}{\sqrt{2}}\right)^2 \times R_r = \left(\frac{0.125}{\sqrt{2}}\right)^2 \times 73$$

$$= 0.57 \text{ W}$$

52. (a)

$$\eta_{max} = \frac{x(\text{kVA})\cos\phi_2}{x(\text{kVA})\cos\phi_2 + 2P_i}$$

$\because$ At maximum efficiency, the variable loss is equal to the constant loss.

$$0.8 = \frac{0.8 \times 100 \times 10^3 \times 0.8}{0.8 \times 100 \times 10^3 \times 0.8 + 2P_i}$$

$$0.8 = \frac{64000}{64000 + 2P_i}$$

$$P_i = 8 \text{ kW} = P_c$$

53. (d)

All the statements are correct.

54. (c)

55. (a)

$$E = \sqrt{P_d \eta} = \frac{\sqrt{30 P_t G_t}}{d} \text{ volt/meter}$$

$$6 \times d = \sqrt{30 P_t G_t}$$

$$6 \times 10 \times 1000 = \sqrt{30 P_t G_t}$$

$$\sqrt{30 P_t G_t} = 6 \times 10^4$$

Given: $G_t = 30 \text{ dB} \Rightarrow 1000$

$$\sqrt{30 \times P_t \times 1000} = 6 \times 10^4$$

$$P_t \times 3 \times 10^4 = 36 \times 10^8$$

$$P_t = 120 \text{ kW}$$

Hence, the correct option is (a).

56. (c)

- The 8051 microcontroller has an 8-bit data bus; hence, it is an 8-bit microcontroller.
- There are five specified interrupts in the 8051.
  - → 2-External interrupts (INT0, INT1)
  - → 2-Timer interrupts (TF0, TF1)
  - → 1-Serial Interrupt (RI, TI)
- The 8051 has an 8-bit flag register in which 6 bits are defined, as given below, and two unused bits are user-defined flags:
  1. CY → Carry flag
  2. AC → Auxiliary carry flag
  3. P → Parity flag
  4. OV → Overflow flag
  5. RS1 } Register select bits used to select the register bank
  6. RS0 }
- The SCON (serial control) register is used to program the start bit, stop bit, and data bits for framing in serial communication.

57. (a)

Variable-capacitance diodes are used under reverse-bias conditions.

58. (d)

For option (d):

$$\text{Centroid} = \frac{\Sigma \text{Real part of poles} - \Sigma \text{Real part of zeros}}{\text{Number of poles} - \text{Number of zeros}}$$

$$\sigma = -\frac{6}{3} = -2$$

Break points coincide at $s = -2$.

59. (d)

f_{m_1} = 3 kHz, f_{m_2} = 1.5 kHz, f_{m_3} = 1.5 kHz

∴ f_{s_1} = 6 kHz, f_{s_2} = 3 kHz, f_{s_3} = 3 kHz

The overall sampling rate = 6 + 3 + 3 = 12 kHz

∴ Speed in samples per second = 12000 samples/s

Number of samples in one minute = 12000 × 60 samples

In one 1 rotation, the total number of samples taken = 1 + 1 + 1 = 3

Thus, 3 samples correspond to 1 rotation.

12000 × 60 samples are taken per minute speed of commutator = $\frac{1\times 12000\times 60}{3}$ rotations/min

∴ Speed of commutator = 240000 rpm

60. (b)

Given data:

Distance, d = 60 km

Frequency, f = 450 MHz

Current, I = 0.05 A

Transmitting antenna height, h_t = 120 m

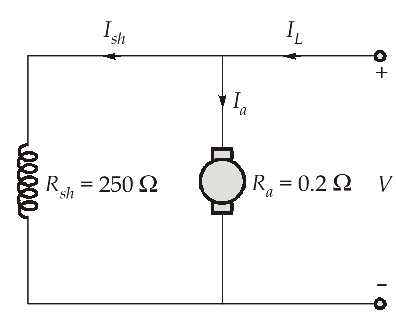
Receiving antenna height, h_r = 40 m

Received electric field:
$$|E_r| = \frac{240\pi I\, h_1\, h_2}{\lambda d^2}$$

$$|E_r| = \frac{240\pi\times 0.05\times 40\times 120\times 450\times 10^6}{3\times 10^8\times (60\times 10^3)^2}$$

$$= 75.3\times 10^{-6}\ \text{V/m}$$

61. (a)



$$I_{sh} = \frac{V}{R_{sh}} = \frac{250}{250} = 1\ \text{A}$$

$$I_L = I_a + I_{sh}$$

$$I_a = I_L - I_{sh}$$

$$= 5 - 1$$

$$= 4\ \text{A}$$

At no load, back emf:
$$E_1 = V - I_a R_a$$

$$= 250 - (4\times 0.2)$$

$$= 249.2\ \text{Volt}$$

When load is applied: $I_L = 50$ A

$$I_a = I_L - I_{sh} = 50 - 1 = 49 \text{ A}$$

$$E_2 = V - I_a R_a$$

$$= 250 - (0.2 \times 49) = 240.2 \text{ V}$$

Given, $\phi_2 = 0.97\ \phi_1$; speed relation: $N \propto \dfrac{E}{\phi}$

$$\frac{N_1}{N_2} = \frac{E_1}{\phi_1} \times \frac{\phi_2}{E_2}$$

$$\frac{N_1}{N_2} = \frac{249.2 \times 0.97\phi_1}{240.2 \times \phi_1}$$

$$N_2 = \frac{N_1 \times 240.2\phi_1}{249.2 \times 0.97\phi_1}$$

Given: $N_1 = 1000$ rpm

$$N_2 = \frac{1000 \times 240.2}{249.2 \times 0.97}$$

$$N_2 = 993.7 \text{ rpm} \quad \text{or} \quad N_2 \cong 994 \text{ rpm}$$

62. (a)

$$\text{Power, } P = I \cdot V = (-2)(8) = -16 \text{ W}$$

63. (c)

Frequency sampling realization of an FIR filter uses poles and zeros at equally spaced points on the unit circle to implement the filter.

64. (b)

$$h(t) = 4e^{-2t}u(t),\ m_y = 5$$

$$H(\omega) = \frac{4}{j\omega + 2}$$

$$|H(0)| = \frac{4}{\sqrt{(0)^2 + (2)^2}} = \frac{4}{2} = 2$$

We know, $m_y = |H(0)|\, m_x$

$$5 = \frac{4}{2} \times m_x$$

$$m_x = 2.5$$

65. (b)

The channel thickness is inversely related to the square root of the doping concentration of the channel. This is because the depletion width,

$$W \propto \frac{1}{\sqrt{\text{Doping}}}$$

66. (d)

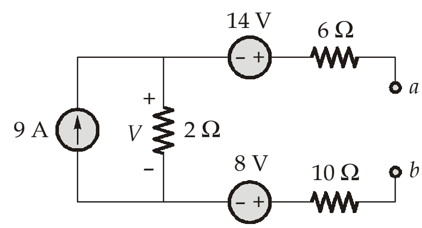
To enable multiprocessing capabilities, the 8086 microprocessor must operate in maximum mode, which occurs when the pin $MN/\overline{MX}$ is low (connected to ground).

67. (c)

The equivalent resistance is given by:

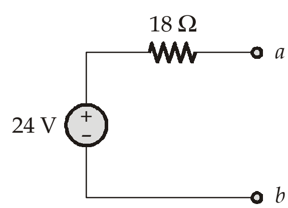
$$R_{eq} = (6\,\Omega \| 3\,\Omega) + 6\,\Omega + 10\,\Omega = 18\,\Omega$$

and V_{ab} =



$$V_{ab} = 14 + 9 \times 2 - 8 = 24\text{ V}$$

Thevenin equivalent acorss *ab* is



68. (d)

Given: $x(t) = e^{-t}u(t)$

Taking the Laplace transform,

$$X(s) = \frac{1}{s+1}$$

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

$$L^{-1}[X(2s)] = L^{-1}\left[\frac{1}{2s+1}\right]$$

$$= L^{-1}\left[\frac{\frac{1}{2}}{s+\frac{1}{2}}\right]$$

$$= \frac{1}{2}e^{-t/2}u(t)$$

$$e^{-3s}X(2s) = L^{-1}[X(2s)]_{t \to t-3}$$

$$= \frac{1}{2}e^{-t/2}u(t)\Big|_{t \to t-3}$$

$$= \frac{1}{2}e^{\frac{-(t-3)}{2}}u(t-3)$$

69. (b)

$$\text{Symbol rate, } R_s = \frac{R_b}{\log_2 M}$$

where $\log_2 M$ is the number of bits to be represented by each symbol.

$$2400 = \frac{19.2 \times 1000}{\log_2 M}$$

$$\log_2 M = \frac{19.2}{2.4} = 8$$

$$M = 2^8 = 256$$

Since the bandwidth efficiency is 1 bps/Hz, the initial bandwidth is:

$$\text{Bandwidth} = 2400 \text{ Hz}$$

$$= \text{transmission rate}$$

After increasing the data rate,

$$\text{Bandwidth efficiency } (\eta) = \frac{R_b}{B.W} = \frac{19.2 \text{ kbps}}{2400 \text{ bps}}$$

$$\eta = \frac{19200}{2400} = 8 \text{ bps/Hz}$$

70. (c)

By using plane normals:

$$n_1 = (110)$$

$$n_2 = (101)$$

$\therefore$ $$\cos\phi = \frac{(n_1)\cdot(n_2)}{|n_1|\cdot|n_2|}$$

$$= \frac{1.1 + 1.0 + 0.1}{\sqrt{1^2+1^2+0^2}\sqrt{1^2+0^2+1^2}}$$

$$= \frac{1}{\sqrt{2}\cdot\sqrt{2}} = \frac{1}{2}$$

$\therefore$ $$\phi = \cos^{-1}(0.5) = 60^\circ$$

71. (d)

Given: $$\vec{E} = \hat{a}_y 10 e^{-j(6x+8z)} \text{ V/m}$$

$$\epsilon_r = 2.25$$

$$\text{Phase velocity, } V_p = \frac{\omega}{\beta}$$

where, $$\beta = \sqrt{6^2+8^2} = 10$$

$\therefore$ $$\frac{3\times10^8}{\sqrt{\epsilon_r}} = \frac{\omega}{10}$$

$$\therefore \quad \frac{3\times 10^8}{1.5} = \frac{\omega}{10}$$

$$\therefore \quad \omega = 2 \times 10^9 \text{ rad/sec}$$

72. (c)

In an intrinsic semiconductor, the free electron concentration (n) primarily depends on temperature (T) and the material's band gap energy (E_g).

$$n \propto T^{3/2} e^{-E_g/2kT}$$

73. (c)

Given, $$G(j\omega) = \frac{K}{(j\omega)(0.2j\omega+1)(j0.05\omega+1)}$$

The phase cross-over frequency is given by

$$\angle G(j\omega)H(j\omega)\big|_{\omega=\omega_{pc}} = -180°$$

$$-180° = -90° - \tan^{-1}\frac{0.2\omega_{pc}}{1} - \tan^{-1}\frac{0.05\omega_{pc}}{1}$$

$$-90° = -\tan^{-1}\left[\frac{0.2\omega_{pc}+0.05\omega_{pc}}{1-(0.2\times 0.05)\omega_{pc}^2}\right]$$

$$\tan 90° = \frac{0.25\omega_{pc}}{1-0.01\omega_{pc}^2}$$

(or) $$1-0.01\omega_{pc}^2 = 0$$

$$\Rightarrow \quad \omega_{pc}^2 = 100$$

$$\therefore \quad \omega_{pc} = 10 \text{ rad/s}$$

74. (b)

Given: Gauge factor, $GF = 2$

Stress, $S = 1020 \text{ kg/cm}^2$

Modulus of elasticity, $E = 2 \times 10^6 \text{ kg/cm}^2$

Sensitivity of strain gauge, $$\frac{\Delta R}{R} = GF \times \text{strain}$$

$$\Rightarrow \quad \frac{\Delta R}{R} = 2\times\frac{S}{E} = 2\times\frac{1020}{2\times 10^6}$$

$$\Rightarrow \quad \frac{\Delta R}{R} = 1.02 \times 10^{-3}$$

Hence, percentage resistance change = 0.102%

75. (d)

Magnitude of the Burgers vector:

$$|b| = \frac{1}{2}\times a\times\sqrt{h^2+k^2+l^2}$$

$$= \frac{1}{2}\times 3\times\sqrt{1^2+1^2+1^2} = \frac{1}{2}\times 3\times\sqrt{3}$$
$$= 2.59\ \text{Å}$$

76. (a)

$$\text{LXI H, 01FFH} \rightarrow \text{H} \rightarrow \text{01H}$$
$$\text{L} \rightarrow \text{FFH}$$
$$\text{SHLD 2050H} \rightarrow \text{2050H} \rightarrow \text{FFH}$$
$$\text{2051H} \rightarrow \text{01H}$$

77. (b)

The drain current equation for a MOSFET operating in saturation is

$$I_d = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_T)^2$$

Given, $I_d = 5\ \mu\text{A}$

$$5\times 10^{-6} = \frac{1}{2}\times\frac{30}{2}\times 300\times 2.6\times 10^{-7}\,(V_{GS}-0.5)^2$$

For the MOSFET to remain in saturation:

$$V_{DS} = V_{GS} - V_T = 0.59 - 0.5 = 0.09\ \text{V}$$

∴ The minimum drain-to-source voltage required to ensure saturation is 0.09 V.

78. (a)

Given, $A = \begin{bmatrix}1 & 0\\ 2 & 3\end{bmatrix},\ B = \begin{bmatrix}1\\ 0\end{bmatrix},\ C = [1\ \ 0]$

For the system to be controllable:

$$|Q_c| \neq 0 \quad ; \quad Q_c = [B \quad AB]$$

$$Q_c = \begin{bmatrix}1 & 1\\ 0 & 2\end{bmatrix} \Rightarrow |Q_c| = 2-0 = 2 \neq 0$$

∴ The system is controllable.

For the system to be observable:

$$|Q_0| \neq 0 \quad ; \quad Q_0 = [C^T \quad A^T C^T]$$

∴ $$\begin{bmatrix}1 & 1\\ 0 & 0\end{bmatrix} = Q_0$$

$$|Q_0| = 0$$

∴ The system is not observable.

79. (b)

Given, Deflection of the spring, $\theta = \dfrac{T}{K_s}$

given, Torque, $T = 0.01\times 10^{-5}$ Nm

Spring constant, $K_s = 0.5\ \mu$Nm/degree

$$= 0.5 \times 10^{-6} \text{ Nm/degree}$$

$$\therefore \quad \text{Spring constant, } \theta = \frac{0.01\times10^{-5}}{0.5\times10^{-6}} = 0.2°$$

80. (c)

The transmitter's window size is N.

The receiver's window size is M.

In a sliding window ARQ scheme, the sending process transmits a number of frames without waiting to receive an ACK packet, upto a certain limit called the window size. The maximum number of unacknowledged packets at the sender is M, and at the receiver it is N. Therefore, for the scheme to operate correctly, a total of $M + N$ distinct sequence numbers is required.

81. (c)

Trap Flag (TF): If this flag is set to 1, the program runs in single-step mode. It is used for debugging.

Directional Flag (DF): It is used in string operations to access strings from higher to lower memory addresses and vice-versa.

Interrupt Flag (IF): It is used to enable interrupts in the 8086.

Zero Flag (ZF): It is set to 1 when the result of an arithmetic operation is zero.

82. (b)

Given: $I = 5$ mA, $T = 300$ K

Forward resistance: $$r_f = \frac{\eta V_T}{I}$$

Theremal voltage: $$V_T = \frac{T}{11600}$$

$$r_f = \frac{2\times\frac{300}{11600}}{5\times10^{-3}} = 10.34\ \Omega$$

83. (a)

$$C_n = \frac{1}{T}\int_0^T x(t)\, e^{-jn\omega_o t}\, dt$$

$$C_{-n} = \frac{1}{T}\int_0^T x(t)\, e^{jn\omega_o t}\, dt = C_n^*$$

$$C_n = \frac{a_n - jb_n}{2}$$

$$C_{-n} = C_n^* = \frac{a_n + jb_n}{2}$$

$$a_n = C_n + C_{-n}$$

84. (b)

$$g(t) = s(t)\ c(t)$$
$$= x(t)\cos(\omega_c t) \times \cos(\omega_c t + \phi)$$
$$= \frac{x(t)}{2}\cos(2\omega_c t + \phi) + \frac{x(t)}{2}\cos\phi$$

After passing through the LPF,

$$g'(t) = \frac{x(t)}{2}\cos(\phi)$$

Given that the recovered signal is 50% of the maximum value:

$$\cos(\phi_{max}) = \frac{0.5\left[\frac{x(t)}{2}\cos\phi\right]_{max}}{\frac{x(t)}{2}} = 0.5$$

$$\phi_{max} = \cos^{-1}\left(\frac{1}{2}\right) = 60°$$

85. (d)

Nanomaterials are widely used in sunscreens due to their enhanced UV-blocking abilities, increased cosmetic appeal, and improved functionality compared to traditional larger-sized mineral particles. Nanoparticles such as titanium dioxide and zinc oxide are effective in absorbing, scattering, and reflecting UV radiation, making them highly effective in shielding the skin from both UVA and UVB rays.

86. (c)

LXI B, 0007H $\Rightarrow$ B $\leftarrow$ 00H
C $\leftarrow$ 07H

Loop: DCX B $\Rightarrow$ 0006H
MOV A, B $\Rightarrow$ A $\leftarrow$ 00H
ORA C $\Rightarrow$ A $\leftarrow$ 06H

The Loop will be executed 7 times until the value of the BC register becomes 00H.

87. (a)

88. (b)

Given: $P = 0$

$$N = Z - P \quad \Rightarrow N = 2$$

$\therefore$ $Z = 2$

89. (b)

For a square-law response,

Deflection torque, $T_D = KI^2$

Also, $T_D = C\theta$

Hence, $I^2 \propto \theta$

$$\frac{I'^2}{I^2} = \frac{\theta'}{\theta} = \frac{\pi/4}{\pi/2} = \frac{1}{2}$$

$$\therefore \quad I' = \frac{1}{\sqrt{2}} = 0.707\,\text{A}$$

90. (c)

- For a multimode fiber, the critical radius of curvature is given by: $R_c = \dfrac{3n_1^2\lambda}{4\pi(n_1^2 - n_2^2)^{3/2}}$

  Whereas, for a single-mode fiber, the critical radius of curvature is given by

$$R_c \approx \frac{20\lambda}{(n_1^2 - n_2^2)^{3/2}}\left(2.748 - 0.996\left(\frac{\lambda}{\lambda_c}\right)\right)^{-3}$$

  where $$\Delta = \frac{n_1 - n_2}{n_1}$$

- In graded-index multimode fibers, the effect of modal dispersion is significantly reduced because the speed of light inside the core varies with the refractive index. Therefore, dispersion in a multimode graded-index fiber is less than that of a multimode step-index fiber.

Hence, statements 1 and 2 are incorrect.

91. (c)

PUSH *a*	→	Put *a* onto the stack
PUSH *b*	→	Put *b* onto the stack
PUSH *c*	→	Put *c* onto the stack
POP AX	→	Store *c* in AX
POP BX	→	Store *b* in BX
SUB AX, BX	→	Store $(c - b)$ in AX
POP BX	→	Store *a* in BX
ADD AX, BX	→	Store $(c - b + a)$ in AX

Finally, after execution, the content of AX is $(c - b + a)$.

92. (c)

93. (c)

The settling time for a 2% tolerance is equal to 4τ i.e., $T_s = \dfrac{4}{\xi\omega_n}$

Given: $4\tau = 0.04$

$$\Rightarrow \quad \tau = 0.01 = 10\text{ ms}$$

94. (d)

Given, $$P(x_1) = P(x_2) = 0.5$$

$$P[Y] = P[X]\cdot P\left[\frac{Y}{X}\right]$$

$$= \begin{bmatrix} 0.5 & 0.5 \end{bmatrix} \begin{bmatrix} 0.8 & 0.2 & 0 \\ 0 & 0.2 & 0.8 \end{bmatrix}$$

$$P[Y] = \begin{bmatrix} 0.4 & 0.2 & 0.4 \end{bmatrix}$$

$$P(y_1) = 0.4$$

95. (b)

We know that,

$$\text{Time period of a satellite } (T) = \frac{2\pi r}{v} = \frac{2\pi}{\sqrt{GM}} r^{3/2} \text{ seconds}$$

Substituting the value of G and M:

$$T = 3.14 \times 10^{-7}\, r^{3/2} \text{ seconds}$$

Given: $T = 3.14 \times 10^{4}$ second

$$3.14 \times 10^4 = 3.14 \times 10^{-7}\, r^{3/2}$$

$$r^{3/2} = 10^{11} \text{ m}$$

$$r = (10^{11})^{2/3} \text{ m}$$

$$r = 10^6 \times (10)^{4/3} \text{ m}$$

$$r \cong 21544 \text{ km}$$

$$r = a + h$$

$$21544 = a + 6400$$

$$a = 15144 \text{ km}$$

$$\text{Length of the major axis} = 2a$$

$$= 30288 \text{ km}$$

96. (b)

The value of N is calculated as follows:

The time required to execute this routine:

$$t = [10 + N \times (6 + 4 + 4) + (N - 1) \times 10 + 7]T$$

$$2 \times 10^{-3} = [10 + 14N + 10N - 10 + 7]320 \times 10^{-9}$$

On solving, $N = 260.125$

$$N \cong 260$$

97. (c)

$$P_{D(\text{rated})} = P_{D\,(\max)} - [(\text{derating factor}) \times \Delta T]$$

$$= 400 \text{ mW} - (3.2 \text{ mW/°C}) \times (90°\text{C} - 50°\text{C})$$

$$= 272 \text{ mW}$$

98. (a)

$$X(z) = \sum_{n=-\infty}^{\infty} e^{jn\frac{\pi}{2}} z^{-n}\, u(n) = \sum_{n=0}^{\infty} (e^{j\frac{\pi}{2}} z^{-1})^n$$

$$= \frac{1}{1 - e^{j\frac{\pi}{2}} z^{-1}} \;;\; |z| > \left| e^{j\frac{\pi}{2}} \right| = \frac{z}{z - j} \;;\; \text{ROC} : |z| > 1$$

99. (b)

Upon comparing the output with the standard AM signal, we get:

$$A_c = 14.14$$

$$B = \frac{A_c \mu}{2}$$

Given, $\mu = 0.7$

$$B = \frac{14.14 \times 0.7}{2} = 4.949$$

100. (c)

$$\beta = \frac{\Delta f}{f_m}$$

$$\beta_{\min} = \frac{80 \times 10^3}{20 \times 10^3} = 4$$

$$\beta_{\max} = \frac{80 \times 10^3}{50} = 1600$$

If $\beta_1 = 0.4$ where β_1 is the input modulation index, then the required frequency multiplication is

$$n = \frac{\beta_{\max}}{\beta_1} = \frac{1600}{0.4} = 4000$$

The maximum allowable frequency deviation at the input, denoted as Δf_1 is

$$\Delta f_1 = \frac{\Delta f}{n} = \frac{80 \times 10^3}{4 \times 10^3} = 20 \text{ Hz}$$

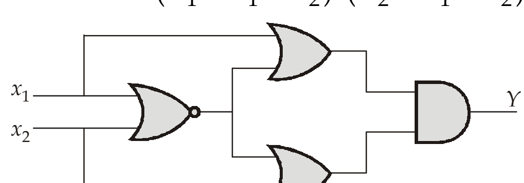
101. (d)

Resistances R and R_E constitute the feedback network. R is directly connected to the input node; hence, shunt mixing and not directly connected to the output node; hence current sampling. Hence, the feedback is current shunt feedback.

102. (d)

OR-AND logic is equivalent to NOR-NOR logic. Hence, we get

$$Y = (X_1 + \overline{X_1 + X_2}) \cdot (X_2 + \overline{X_1 + X_2})$$



$$Y = (X_1 + \overline{X_1} \cdot \overline{X_2}) \cdot (X_2 + \overline{X_1} \cdot \overline{X_2})$$

$$Y = (X_1 + \overline{X_2})(X_1 + \overline{X_1})(X_2 + \overline{X_1})(X_2 + \overline{X_2})$$

$$Y = (X_1 + \overline{X_2})(X_2 + \overline{X_1})$$

$$Y = X_1 X_2 + \overline{X_1} \cdot \overline{X_2} = X_1 \odot X_2 = \overline{X_1 \oplus X_2}$$

103. (a)

If V_0 = +10 V, D_1 is ON

$$\therefore \quad V_{UT} = \frac{V_0 \times 3}{1+3} = \frac{10\times 3}{4} = 7.5 \text{ V}$$

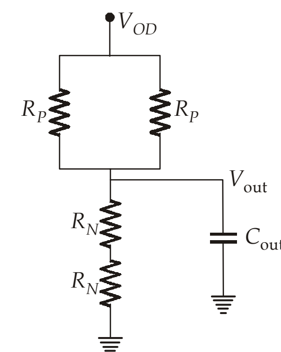
If V_0 = –10 V, D_2 is ON

$$\therefore \quad V_{LT} = \frac{V_0 \times 3}{3+2} = \frac{-10\times 3}{5} = -6 \text{ V}$$

$$\text{Hysteresis width } (V_H) = V_{UT} - V_{LT}$$
$$= 7.5 - (-6)$$
$$V_H = 13.5 \text{ V}$$

104. (d)

A CMOS NAND gate can be represented as shown:



In the circuit, $R_{eqp} = \frac{R_P}{2}$

and $R_{eqn} = 2R_N$

Also since, $R_N \propto \frac{L_N}{W_N} \times \frac{1}{\mu_N}$; $\quad R_P \propto \frac{L_P}{W_P} \times \frac{1}{\mu_P}$

$$\Rightarrow \quad \frac{R_N}{R_P} = \frac{\mu_P}{\mu_N}$$

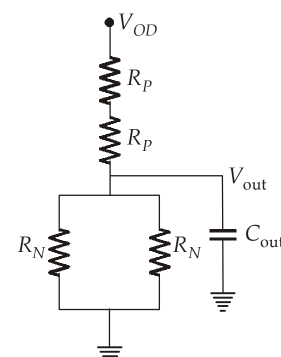
$$\Rightarrow \quad R_N \cong \frac{R_P}{2.5} \quad [\because \mu_N \cong 2.5\mu_P]$$

So, $R_{eqp} \cong 1.25\ R_{eqn}$

Since the switching time is proportional to resistance, the charging time and discharging time will not differ much.

Whereas, in a NOR circuit, $R_{eqp} \cong 10R_{eqn}$

$$\tau_{charging} \cong 10\ \tau_{discharging}$$



105. (d)

- Attributes are the properties that define an entity type.
  For example: – Roll number, Name, DOB, etc......
- The different types of attributes in the ER model include:
  - Key Attributes: Uniquely identify an entity in the entity set.
  - Composite Attributes: Can be split into components.
  - Multi-valued Attributes: Take up more than a single value for each entity instance.
  - Derived Attributes: Can be derived from other attributes.
  - Simple Attributes: Cannot be further subdivided into components.
  - Single-valued Attributes: Take only a single value for each entity instance.

106. (b)

In an nMOS device, the gate material could be metal or polysilicon. This polysilicon layer is heavily doped polysilicon, deposited by CVD.

107. (d)

- For the given relational schema, the candidate key is AB. Therefore, the primary attributes are A, B and non-primary attributes are C, D, E, P, G.
- B $\rightarrow$ G indicates that there is a partial dependency in the given relational schema (A partial dependency occurs when a non-prime attribute depends functionally on a part of the given candidate key). Hence, the schema is not in 2NF.

108. (a)

For a CLC filter, the ripple factor 'r' is given by

$$r = \frac{\sqrt{2}|X_C|^2}{R_L|X_L|}$$

$$= \frac{\sqrt{2}}{2000} \times \frac{1}{(2\omega_0 C)^2} \times \frac{1}{2\omega_0 L}$$

$$= \frac{\sqrt{2}}{2000} \times \frac{10^{12}}{(2 \times 2\pi \times 50 \times 10)^2} \times \frac{1}{2 \times 2\pi \times 50 \times 0.318}$$

$$= \frac{\sqrt{2} \times 10^9}{2 \times 4 \times 10^7} \times \frac{1}{200}$$

$$r = 88.38 \times 10^{-3}$$

109. (b)

$$F(A, B, C) = \Sigma(1, 3, 5, 6)$$

The corresponding mapping table is,

	D_0	D_1	D_2	D_3
$\bar{A}$	0	(1)	2	(3)
A	4	(5)	(6)	7
	0	1	A	$\bar{A}$

Implementation using a 4 × 1 multiplexer:

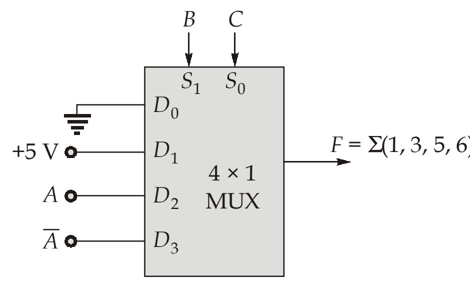
Select lines: $S_1 = B$, $S_0 = C$

Data inputs: $D_0 = 0$

$D_1 = +5$ V

$D_2 = A$

$D_3 = \bar{A}$



110. (c)

Given:
$$P_{D(max)} = 400 \text{ mW}, T_A = 25°C$$
$$\text{Derating factor} = 2.5 \text{ mW/°C}, T_j = 65°C$$

The derating factor of a transistor is the amount by which the power dissipation rating of a transistor decreases when the transistor junction temperature increases. Hence,

$$\Delta P_D = 2.5 \times (65 - 25)$$
$$= 100 \text{ mW}$$
$$\text{Power rating at } 65°C = 400 - 100$$
$$= 300 \text{ mW}$$

111. (a)

In order to satisfy the HOLD time of the register, the input to the register must remain stable untill t_{HOLD} after the clock edge.

The fastest that a new change can propagate to the input of the register is found by taking the sum of the contamination delays along the shortest path to the input.

$$t_{HOLD} \leq t_{cd(register)} + t_{cd(logic)}$$
$$\leq 0.1 + 0.2$$
$$t_{HOLD} \leq 0.3 \text{ ns}$$

The largest value of the register's HOLD time is $t_{HOLD} = 0.3$ ns

The clock period must be long enough for the data to pass through the entire circuit and be ready and stable for set up before the next clock period begins. The data in this circuit must propagate through the register and the combinational logic.

∴ Clock period is

$$t_{clk} \geq t_{pd(reg)} + t_{pd(logic)} + t_{setup(reg)}$$
$$\geq 5 + 3 + 2$$
$$t_{clk} \geq 10 \text{ ns}$$

∴ The smallest value of $t_{clk} = 10$ ns

112. (a)

Given:
$$V_{DS} = 2.5 \text{ V}$$
$$V_{GS} = 1 \text{ V}$$
$$V_{TN} = 0.25 \text{ V}$$

Since $V_{DS} > V_{GS} - V_T$, transistor is in saturation region.

Therefore, the drain current is given by:

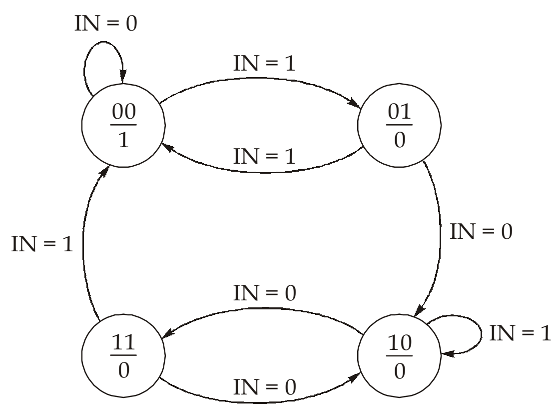
$$\therefore \quad I_D = \frac{K_n}{2}(V_{GS} - V_{TN})^2$$

$$= \frac{1.2}{2}(1 - 0.25)^2$$

$$= \frac{1.2}{2} \times \frac{3}{4} \times \frac{3}{4} = 0.3375 \text{ mA}$$

So, the value of current I_D is 0.3375 mA

113. (c)



S.No.	S_1	S_0	IN	S_1'	S_0'	S_1
0	0	0	0	0	0	1
1	0	0	1	0	1	1
2	0	1	0	1	0	0
3	0	1	1	0	0	0
4	1	0	0	1	1	0
5	1	0	1	1	0	0
6	1	1	0	1	0	0
7	1	1	1	0	0	0

114. (c)

Process	Arrival time	Burst time	CT	TAT	WT
P_1	0	6	12	12	6
P_2	1	4	7	6	2
P_3	3	8	20	17	9
P_4	2	2	4	2	0

Gantt chart:

P1	P2	P4	P4	P2	P2	P2	P1	P3

0 1 2 3 4 5 6 7 12 20

$$TAT = CT - AT \text{ and } WT = TAT - BT$$

$$\text{Average WT} = \frac{6+2+9+0}{4} = \frac{17}{4} = 4.25 \text{ ms}$$

115. (a)

116. (b)

← 24 bits →

TAG	SET OFFSET	WO

(SET OFFSET: ← 5 bits →, WO: ← 9 bits →)

$$\text{Main memory size} = 32768 \times 512$$
$$= 2^{15} \times 2^{9} = 2^{24} \text{ bytes}$$

Hence, 24 bits are required to access the cache memory.

$$\text{Word offset} = \log_2[512] = 9 \text{ bits}$$

$$\text{Number of sets} = \frac{128}{4} = 32$$

$$\text{Set offset} = \log_5 32 = 5 \text{ bits}$$

$$TAG = 24 - 5 - 9 = 10 \text{ bits}$$

117. (d)

$$\text{Rise time, } t_r = 1.1\sqrt{t_{r_1}^2 + t_{r_2}^2}$$
$$= 1.1\sqrt{(0.5)^2 + (1.2)^2}$$
$$= 1.43 \text{ ms}$$

118. (c)

The given circuit is a Binary ripple up counter. The output is cleared when $Q_B Q_C = 11$, corresponding to the state:

Q_C	Q_B	Q_A
1	1	0

Hence, the circuit operates as a MOD-6 ripple counter.

119. (d)

Given: $I_{DSS} = 18$ mA, $V_{GS(\text{off})} = -6$ V

$g_{m0} = 6$ m℧

We know,

$$g_m = g_{m0}\left(1 - \frac{V_{GS}}{V_{GS(\text{off})}}\right)$$

$$4 = 6\left(1 - \frac{V_{GS}}{-6}\right)$$

$$\frac{V_{GS}}{6} = \left(\frac{4}{6} - 1\right)$$

$$V_{GS} = -2 \text{ V}$$

120. (b)

Files and programs can be shared, but a printer cannot be shared.

121. (d)

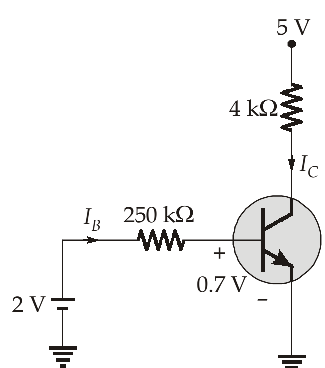
Binary	Gray	Decimal Equivalent
0000	0000	(0)
0001	0001	(1)
0010	0011	(3)
0011	0010	(2)
0100	0110	(6)
0101	0111	(7)
0110	0101	(5)
0111	0100	(4)
1000	1100	(12)
1001	1101	(13)

$\therefore$ Addition of thedecimal equivalents of all Gray codes:

1 + 3 + 2 + 6 + 7 + 5 + 4 + 12 + 13 = 53

122. (b)

Drawing the Thevenin's equivalent, we have



$$I_B = \frac{2-0.7}{250} \times 10^{-3} = 5.2\ \mu A$$

$$I_C = 120 \times 5.2 \times 10^{-6} = 0.624\ \text{mA}$$

$$g_m = \frac{I_C}{V_T} = \frac{0.624}{25.9} \approx 24\ \text{mA/V}$$

$\therefore$ Voltage gain, $A_v = \frac{V_0}{V_i} = -g_m R_C = -24 \times 10^{-3} \times 4 \times 10^3 = -96$

Hence, $|A_V| = 96$

123. (b)

Initially, before the clock pulse, the D-flip flop output is 0 and input of the XOR gate is 0 and b_7.

So, after 1 clock pulses: $b_7 \oplus 0 = b_7$

after 2 clock pulses: $b_7 \oplus b_6$

after 3 clock pulses: $b_6 \oplus b_5$

Hence, the circuit works as a binary to gray code converter.

124. (a)

- For the ECL logic family, the logic levels are negative, with logic 1 having a level of –0.9 V and logic 0 having a level of –1.7 V, which are not compatible with other logic family gates.
- In ECL, current is continuously drawn, hence dissipating significantly more power than other logic families.

125. (a)

The above circuit is a voltage tripler circuit, thus, the output voltage is equal to

$$V_0 = 3 \times V_{peak} \qquad (\because R_L \to \infty)$$
$$= 3 \times 5 = 15 \text{ V}$$

126. (d)

A Darlington pair is a connection of common-collector amplifiers. The cascode amplifier is a two-stage amplifier that consists of a common-emitter stage feeding into a common-base stage. Since, the current gain of a common-base amplifier is unity, the current gain of a cascode amplifier is equivalent to that of a single-stage common-emitter amplifier. Also, the common-base amplifier has wide bandwidth; hence, the cascode amplifier has high bandwidth.

127. (d)

According to the Deal-Grove method of thermal oxidation,

$$\frac{dt_{ox}}{dt} = \frac{B}{A + 2t_{ox}}$$

Hence, as the oxide layer thickness grown on the substrate increases, the growth rate decreases.

128. (d)

The decimal number is 0.425×2^{13}

We have to find the hexadecimal representation without normalization.

$$\text{Biased exponent} = 13 + 64 = 77$$

Representing 77 in binary:

$$(77)_{10} = (1001101)_2$$

Representing the mantissa in binary

$$(0.425)_{10} = 0.011011001100$$

The floating-point representation is as follows:

0	1 0 0 1 1 0 1	0 1 1 0 1 1 0 0

$$\underbrace{0100}_{4}\ \underbrace{1101}_{D}\ \underbrace{0110}_{6}\ \underbrace{1100}_{C}$$

129. (d)

Accessing a random sector requires adjustment for every sector. We have,
9600 revolutions in 60 s

$$\text{Time for one revolution} = \frac{60}{9600} = 6.25 \text{ ms}$$

One revolution corresponds to one track (1024 sectors).

$$\text{Time for one sector} = \frac{6.25\times 1}{1024} \text{ ms} = 6.1\ \mu\text{s}$$

Average rotational latency (no best or worst case):

$$= \frac{1}{2}\times 6.25 = 3.125 \text{ ms}$$

$$T_{avg} = (9.2 + 3.125 + 6.1 \times 10^{-3}) \times 200 \times 10^{-3}$$

$$= 2.46 \text{ s}$$

130. (b)

$$\text{EMAT} = H \times T_c + (1 - H)(T_c + T_m)$$

$$= 0.8 \times 5 + (1 - 0.8)(5 + 100)$$

$$= 0.8 \times 5 + 0.2 \times 105$$

$$\text{EMAT} = 25 \text{ ns}$$

131. (c)

$$(10)_{10} = (1010)_2$$ [Switches D_3 and D_1 are closed]

The current flowing through the 12.5 kΩ branch:

$$I_3 = \frac{5V}{12.5\text{ k}\Omega} = 0.4 \text{ mA}$$

The current flowing through the 50 kΩ branch:

$$I_1 = \frac{5\text{ V}}{50\text{ k}\Omega} = 0.1 \text{ mA}$$

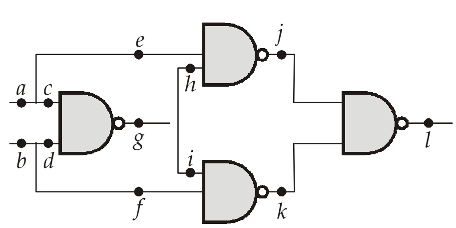
The output voltage is: $V_{out} = -[0.4 \text{ mA} + 0.1 \text{ mA}] \times 20\text{ k}\Omega$

$$= -10 \text{ V}$$

132. (d)

In VLSI design, extraction is the crucial step of analyzing the physical chip layout to identify and quantify unintentional parasitic Resistance (R) and Capacitance (C) (and sometimes Inductance) of wires and components.

133. (b)



Total fault sites = 12

Total number of fault sites in a gate-level circuit = Number of inputs + Number of gates + Number of fan-out branches = 2 + 4 + 6 = 12

134. (d)

A shared-memory multiprocessor fits best into the MIMD classfication.

135. (c)

The metal layer is masked and etched to form the interconnection pattern. The metal layer is formed using aluminium deposited over the formed surface.

136. (b)

A light-sensitive polymer is used to form the photoresist layer. Photoresist is a light-sensitive material used to form a patterned coating on a surface.

137. (a)

Few parts of the photoresist layer are removed by treating the wafer with a basic or acidic solution. Acidic solutions have a pH less than 7, and basic solutions have a pH greater than 7.

138. (c)

The input at which a flip-flop changes its state when synchronized with the clock is called a synchronous control input.

139. (d)

Encoding of the instruction must include the opcode, operands, and address information. Encoding represents the entire instruction as a binary value, therefore, it cannot be pipelined.

140. (a)

141. (c)

$$L[x(t)] = \int_{-\infty}^{\infty} x(t)e^{-st}dt$$

$$F[x(t)] = \int_{-\infty}^{\infty} x(t)e^{-j\omega t}dt$$

$\therefore$ $$L[x(t)] = F[x(t)\, e^{-\sigma t}]$$

Hence, the Laplace transform at $\sigma = 0$ is the Fourier transform.

The ROC of a causal signal is right-sided and does not necessarily include the imaginary axis.

142. (c)

143. (b)

144. (c)

In a photodiode, the photo current and the saturation current are due to minority carrier flow only.

145. (c)

As the DOL starter connects the motor directly to the main supply line, the motor draws a very high current at starting up to 5-8 times the full-load current of the motor.

146. (b)

In an I/O-mapped I/O device, data is transferred from the accumulator to the I/O device and received from I/O device into the accumulator using IN and OUT instructions.

147. (a)

148. (a)

In the RSA algorithm, for encryption, we use $C = P^e(\text{mod } n)$ where C is the cipher text, P is the plain text, e is the public key and for decryption, we use $P = C^d(\text{mod } n)$, where d is the private key.

149. (c)

A material can become superconducting even if none of its individual constituent elements are superconducting.

150. (a)

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