GATE 2019
Instrumentation Engineering

Questions and Solutions of afternoon session

Date of Exam : 3/2/2019

Scroll down to view

www.madeeasy.in

Corporate Office: 44-A/1, Kalu Sarai, New Delhi - 110016 | **Ph:** 011-45124612, 9958995830

Delhi | Hyderabad | Noida | Bhopal | Jaipur | Lucknow | Indore | Pune | Bhubaneswar | Kolkata | Patna

GENERAL APTITUDE

Q.1 - Q.5 Carry One Mark each.

Q.1 The fishermen,_______the flood victims owed their lives, were rewarded by the government.

(a) whom (b) to which
(c) to whom (d) that

Ans. (c)

End of Solution

Q.2 Some students were not involved in the strike.

If the above statement is true, which of the following conclusions is/are logically necessary?

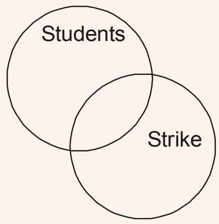
1. Some who were involved in the strike were students.
2. No student was involved in the strike.
3. At least one student was involved in the strike.
4. Some who were not involved in the strike were students.

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

Ans. (c)

Given statements: Some students were not involved in the strike.

Venn diagram:



Only conclusion 4 is logically necessary.

Hence, option (c) is correct.

End of Solution

Q.3 Until Iran came along, India had never been________in kabaddi

(a) defeated (b) defeating
(c) defeat (d) defeatist

Ans. (a)

Until Iran came along, India had never been defeated in Kabaddi.

If two events occur in past one after antoher, the event completing first takes past perfect tense. And another event is expressed in Simple past tense.

End of Solution

Q.4 Five numbers 10, 7, 5,4 and 2 are to be arranged in a sequence from left to right following the directions given below:

1. No two odd or even numbers are next to each other.
2. The second number from the left is exactly half of the left-most number.
3. The middle number is exactly twice the right-most number.

Which is the second number from the right?

(a) 2 (b) 4
(c) 7 (d) 10

Ans. (c)

According to given data the only possible arrangement is

10 5 4 7 2

So, second from right will be 7.

End of Solution

Q.5 The radius as well as the height of a circular cone increases by 10%. The percentage increase in its volume is_______.

(a) 17.1 (b) 21.0
(c) 33.1 (d) 72.8

Ans. (c)

We know formula for volume of a (right circular) cone is $\frac{1}{3}\pi r^2 h$

Original volume (V_0)

$$V_0 = \frac{1}{3}\pi r_1^2 h_1 \qquad \text{... (i)}$$

Now we know radius and height both are increased by 10%. So after increase the new volume will be

$$V_n = \frac{1}{3}\pi(1.1r_1)^2(1.1)h_1$$

$$= 1.331\left(\frac{1}{3}\pi r_1^2 h_1\right)$$

$$= 1.331\,(V_0)$$

$$\%\text{ change in volume} = \frac{V_n - V_0}{V_0}\times 100 = \frac{1.331V_0 - V_0}{V_0}\times 100$$

$$= 33.1\%$$

End of Solution

Q.6 Since the last one year, after a 125 basis point reduction in repo rate by the Reserve Bank of India, banking institutions have been making a demand to reduce interest rates on small saving schemes. Finally, the government announced yesterday a reduction in interest rates on small saving schemes to bring them on par with fixed deposit interest rates.

Which one of the following statements can be inferred from the given passage?

(a) Whenever the Reserve Bank of India reduces the repo rate, the interest rates on small saving schemes are also reduced

(b) Interest rates on small saving schemes are always maintained on par with fixed deposit interest rates

(c) The government sometimes takes into consideration the demands of banking institutions before reducing the interest rates on small saving schemes

(d) A reduction in interest rates on small saving schemes follow only after a reduction in repo rate by the Reserve Bank of India

Ans. (c)

The argument says that banking institutiions had been demanding for a reduction in interest rates for the last one year. Finally the government decided to reduce the interest rates of small saving schemes thus implying that the govt. does consider the demands of banking institutions before making any such policy decision.

End of Solution

Q.7 "I read somewhere that in ancient times the prestige of a kingdom depended upon the number of taxes that it was able to levy on its people. It was very much like the prestige of a head-hunter in his own community."

Based on the paragraph above, the prestige of a head-hunter depended upon_____

(a) the prestige of the kingdom

(b) the prestige of the heads

(c) the number of taxes he could levy

(d) the number of heads he could gather

Ans. (d)

The way prestige of a kingdom depended upon the number of taxes, the prestige of a head-hunter depended upon the number of heads he could collect.

End of Solution

Q.8 In a country of 1400 million population 70% own mobile phones. Among the mobile phone owners, only 294 million access the Internet. Among these Internet users, only half buy goods from e-commerce portals. What is the percentage of these buyers in the country?

(a) 10.50 (b) 14.70

(c) 15.00 (d) 50.00

Ans. (a)

Total population = 1400 million

According to the question 70% of mobile phone users data is an unnecessary data.

Its not necessary to calculate tabing the relevant data into consideration,

Number of internet users = 294 million

Half of which (internet) use e-commerce portal

$$\frac{294}{2} = 147$$

Percentage of thesen (e-commerce portals) in the country (out of 1400 million)

$$= \frac{147}{1400} \times 100 = 10.5\%$$

End of Solution

Q.9 The nomenclature of Hindustani music has changed over the centuries. Since the medieval period *dhrupad* styles were identified as *baanis*. Terms like *gayaki* and *baaj* were used to refer to vocal and instrumental styles, respectively. With the institutionalization of music education the term *gharana* became acceptable. *Gharana* originally referred to hereditary musicians from a particular lineage, including disciples and grand disciples.

Which one of the following pairings is NOT correct?

(a) *dhrupad, baani*
(b) *gayaki*, vocal
(c) *baaj*, institution
(d) *gharana*, lineage

Ans. (c)

Baaj, institution

Following are the correct pairings:

- Dhrupad style - baani
- gayaki - vocal style
- baaj - insturmental style
- gharana - musicians from a particular lineage

End of Solution

Q.10 Two trains started at 7 AM from the same point. The first train travelled north at a speed of 80 km/h and the second train travelled south at a speed of 100 km/h. The time at which they were 540 km apart is ______AM.

(a) 9
(b) 10
(c) 11
(d) 11.30

Ans. (b)

According to the concept of relative speed in opposite direction speeds should be added

$$\text{Time of activity} = \frac{\text{Sum of distance}}{\text{Sum of speeds}} = \frac{540}{100+80} = \frac{540}{180}$$

= 3 hours from 7 am = 10 am

End of Solution

MADE EASY

India's Best Institute for IES, GATE & PSUs

ESE 2019

Mains Classroom Program

Conventional Ques. Practice Program

Commencing from

20th Feb, 2019

These batches are offered only at **Delhi** Centre.

Mains Test Series

Conventional Test Series

Commencing from

17th Mar, 2019

Test series will be conducted at **all MADE EASY** centres across India.

Features :

- Very useful to develop numerical solving approach & improving writing skills.
- Special focus on improving answer layout specially for theory questions.
- Classes will be delivered by senior faculties.
- Updated Mains workbook for every subject having varied practice question sets.
- Test series will be conducted on every Sunday in synchronisation with the subject taught in class.
- Discussion on probable questions.
- Comprehensive and in-depth discussion on variety of conventional questions, thus strengthening fundamental concepts.

Batch Details	Course Duration	Class Duration	Test Series
	90 days | 300 - 350 hours	5-6 days a week and 6-7 hours a day	Every Sunday

Streams	Batch Code	Batch Commencing Date	Venue (Delhi)	Timing
ME	A	20-Feb-2019	Ghitorni Centre	7:30 AM to 1:30 PM
ME	B	20-Feb-2019	Ghitorni Centre	3:00 PM to 9:00 PM
ME	C	20-Feb-2019	Saket Centre	7:30 AM to 1:30 PM
CE	A	21-Feb-2019	Ignou Road Centre	7:30 AM to 1:30 PM
CE	B	21-Feb-2019	Kalu Sarai Centre	3:00 PM to 9:00 PM
EE	A	22-Feb-2019	Lado Sarai Centre	7:30 AM to 1:30 PM
EE	B	22-Feb-2019	Kalu Sarai Centre	3:00 PM to 9:00 PM
EC	A	22-Feb-2019	Lado Sarai Centre	7:30 AM to 1:30 PM

Hostel facility will be arranged

Fee Structure

Program	Ex. MADE EASY Students Enrolled in Postal, Rank Improvement, Mains, GS, Post-GATE, ESE+ GATE, GATE Batches	Non MADE EASY students
Mains Exclusive Batch (Inclusive of ESE-2019 Mains Offline Test Series)	₹ 18,500	₹ 22,500
ESE 2019 Mains Offline Test Series	~~Rs. 3,500/-~~ Rs. 2,500/-	~~Rs. 4,500/-~~ Rs. 3,500/-

Rs. 1000/- Discount on test series valid till **15-02-2019**

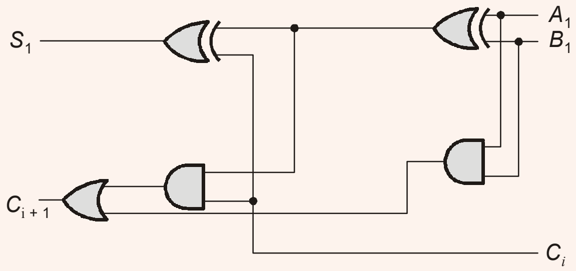
Corporate office : 44-A/1, Kalu Sarai, New Delhi - 1100 16 ✆ 011-45124612, 9958995830

Click here to enroll

INSTRUMENTATION ENGINEERING

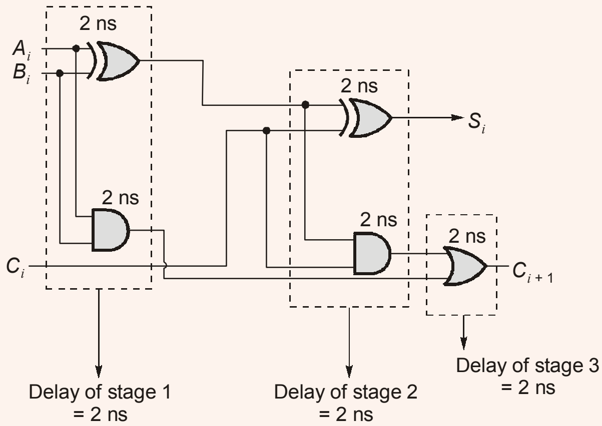
Q.1 - Q.25 Carry One Mark each.

Q.1 The figure below shows the i^{th} full-adder block of a binary adder circuit. C_i is the input carry and C_{i+1} is the output carry of the circuit. Assume that each logic gate has a delay of 2 nanosecond, with no additional time delay due to the interconnecting wires. If the inputs A_i , B_i are available and stable throughout the carry propagation, the maximum time taken for an input C_i to produce a steady-state output C_{i+1} is____nanosecond.



Ans. **(6)**

Given that each logic gate has a delay of 2 ns



∴ total delay for an input C_i to produce $C_{i+1} = 2 + 2 + 2 = 6$ ns.

End of Solution

Q.2 The vector function $\vec{A}$ is given by $\vec{A} = \vec{\nabla} u$, where $u(x, y)$ is a scalar function, Then $|\vec{\nabla} \times \vec{A}|$

(a) –1
(b) 0
(c) 1
(d) ∞

Ans. **(b)**

Given that $u(x, y)$ is a scaler point function,

and $\bar{A} = \nabla u$

$$\nabla \times \bar{A} = \nabla \times (\nabla u) = 0$$

Vector identity Curl (grad ϕ) = 0

End of Solution

Q.3 The loop-gain function $L(s)$ of a control system with unity feedback is given to be $L(s) = \dfrac{k}{(s+1)(s+2)(s+3)}$, where $k > 0$. If the gain cross-over frequency of the loop-gain function is less than its phase cross-over frequency, the closed-loop system is

(a) unstable
(b) marginally stable
(c) conditionally stable
(d) stable

Ans. (d)

$$\text{OLTF} = \frac{k}{(s+1)(s+2)(s+3)}$$

If the $\omega_{gc} < \omega_{pc}$ then that minimum phase system is stable.
Therefore, answer (d)

End of Solution

Q.4 A box has 8 red balls and 8 green balls. Two balls are drawn randomly in succession from the box *without replacement*. The probability that the first ball drawn is red *and* the second ball drawn is green is

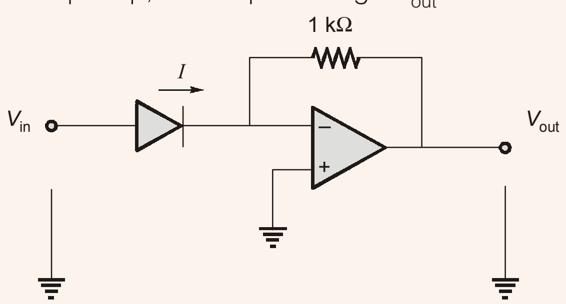
(a) $\dfrac{4}{15}$
(b) $\dfrac{7}{16}$
(c) $\dfrac{1}{2}$
(d) $\dfrac{8}{15}$

Ans. (a)

First is red and second is green $= \dfrac{8}{16} \times \dfrac{8}{15} = \dfrac{4}{15}$

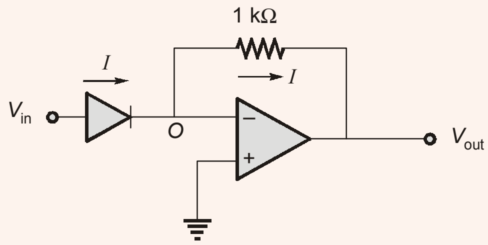
End of Solution

Q.5 In the circuit shown below, the input voltage V_{in} is positive. The current (I)-voltage (V) characteristics of the diode can be assumed to be $I = I_0 e^{V/V_T}$ under the forward bias condition, where V_T is the thermal voltage and I_0 is the reverse saturation current. Assuming an ideal op-amp, the output voltage V_{out} of the circuit is proportional to



(a) $\log_e\left(\dfrac{V_{in}}{V_T}\right)$
(b) $2\,V_{in}$
(c) e^{V_{in}/V_T}
(d) V_{in}^2

Ans. (c)



$$V^{+} = V^{-} = 0 \text{ (Virtual ground)}$$

$$I = I_0 e^{V_D/V_T} = I_0 e^{V_{in}/V_T}$$

$$0 - V_{out} = I \times 1\ \text{k}\Omega$$

$$V_{out} = -I \times 1\ \text{k}\Omega$$

$$V_{out} = -I \times 1\ \text{k}\Omega\ e^{V_{in}/V_T}$$

$$V_{out} \propto e^{V_{in}/V_T}$$

This circuit is an exponential amplifier.

End of Solution

Q.6 In the Figures (a) and (b) shown below, the transformers are identical and ideal, except that the transformer in Figure (b) is centre-tapped. Assuming ideal diodes, the ratio of the root-mean-square (RMS) voltage across the resistor R in Figure (a) to that in Figure (b) is

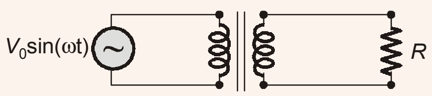


Fig (a)

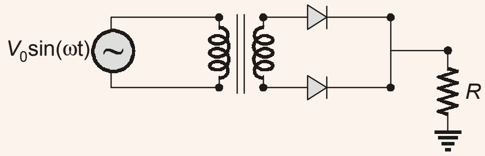


Fig (b)

(a) $\sqrt{2}:1$

(b) 2 : 1

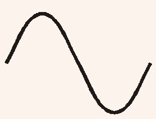
(c) $2\sqrt{2}:1$

(d) 4 : 1

Ans. (b)

Fig (a)

The resultant output V_{01} is



$\longrightarrow$ $V_{0\ rms}$ across $R = \dfrac{V_m}{\sqrt{2}}$

fig (b)

The resultant output V_{02} is

 $\longrightarrow$ $V_{0\ rms}$ across $R = \dfrac{V_m/2}{\sqrt{2}}$

$\dfrac{V_m}{2}$ due to centertap

The ratio $\dfrac{V_{01}}{V_{02}}$ is

$$\frac{V_m/\sqrt{2}}{V_m/2\sqrt{2}} = 2 : 1$$

End of Solution

Q.7 In a single-mode optical fiber, the zero-dispersion wavelength refers to the wavelength at which the

(a) material dispersion is zero

(b) waveguide dispersion is zero.

(c) sum of material dispersion and waveguide dispersion is zero

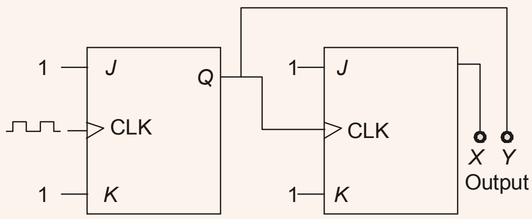
(d) material dispersion and waveguide dispersion are simultaneously zero.

Ans. (c)

In single mode optical fiber 'zero-dispersion' wave length means, sum of material dispersion and waveguide dispersion is zero. So, option (c) is correct answer.

End of Solution

Q.8 The circuit shown in the figure below uses ideal positive edge-triggered synchronous J-K flip flops with outputs X and Y. If the initial state of the output is X = 0 and Y = 0 just before the arrival of the first clock pulse, the state of the output just before the arrival of the second clock pulse is



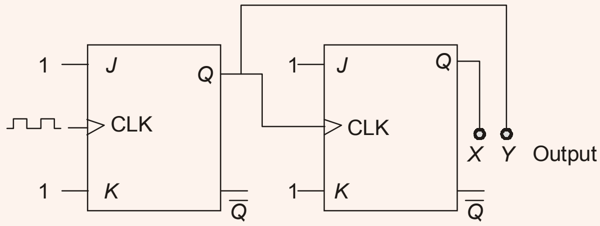
(a) $X = 0, Y = 0$

(b) $X = 0, Y = 1$

(c) $X = 1, Y = 0$

(d) $X = 1, Y = 1$

Ans. (d)



Initial state of output is $x = 0$ and $y = 0$

After 1 Clock pulse, $y = 1$

$\Rightarrow$ $x = 1$

So option (d) is the correct answer.

End of Solution

Q.9 The resistance of a resistor is measured using a voltmeter and an ammeter. The voltage measurements nave a mean value of 1V and standard deviation of 0.12 V while current measurements have a mean value of 1 mA with standard deviation of 0.05 mA. Assuming that the errors in voltage and current measurements are independent, the standard deviation of the calculated resistance value is___________Ω.

Ans. (130)

Given, $R = \frac{V}{I}$

where, $V = 1 \pm 0.12$ V, $I = 1 \pm 0.05$ mA

Here the standard deviation in R (σ_R) will be

$$\sigma_R = \pm\sqrt{\left(\frac{\partial R}{\partial V}\right)^2 \sigma_V^2 + \left(\frac{\partial R}{\partial I}\right)^2 \sigma_I^2}$$

$$\frac{\partial R}{\partial V} = \frac{\partial}{\partial V}\left(\frac{V}{I}\right) = \frac{1}{I} = \frac{1}{10^{-3}} = 10^3$$

$$\frac{\partial R}{\partial I} = \frac{\partial}{\partial I}\left(\frac{V}{I}\right) = -\frac{V}{I^2} = \frac{-1}{10^{-6}} = -10^6$$

$$\sigma_V = 0.12V \text{ and } \sigma_I = 0.05 \text{ mA}$$

Substituting, we have

$$\sigma_R = \sqrt{\left(10^3\right)^2 (0.12)^2 + \left(-10^6\right)^2 \left(0.05 \times 10^{-3}\right)^2}$$

$$= \sqrt{10^6 \times 0.0144 + 10^{12} \times 2.5 \times 10^{-9}}$$

$$= \sqrt{14400 + 2500} = \pm 130\,\Omega$$

End of Solution

Q.10 The correct biasing conditions for typical operation of light emitting diodes, photodiodes, Zener diodes are, respectively

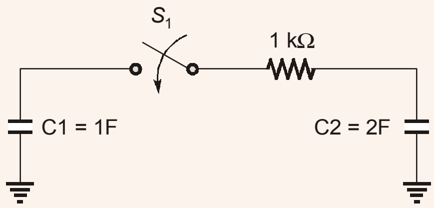
(a) forward bias, reverse bias, reverse bias
(b) reverse bias, reverse bias, forward bias
(c) forward bias, forward bias, reverse bias
(d) reverse bias, forward bias, reverse bias

Ans. (a)

Light emitting diode
LED - Forwarsd bias
Photo diode - Reverse bias
Zener diode - Reverse bias

End of Solution

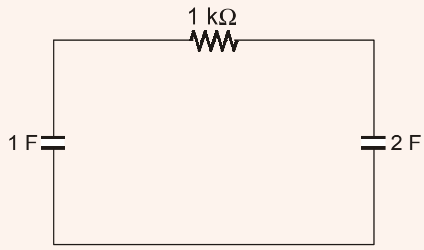
Q.11 In the circuit shown below, initially the switch S_1 is open, the capacitor $C1$ has a charge of 6 coulomb, and the capacitor $C2$ has 0 coulomb. After S_1 is closed, the charge on $C2$ in steady state is__________Coulomb.



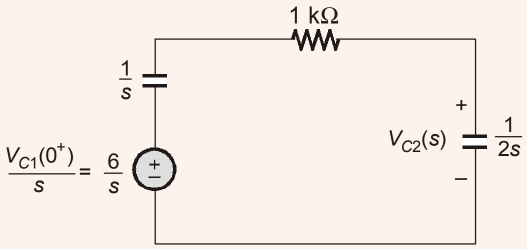
Ans. (4)

$$V_{C1}(0^-) = \frac{6}{1} = 6 \text{ V and } V_{C2}(0^-) = 0 \text{ V}$$

For $t > 0$



Transforming the circuit to the Laplace domain,



$$V_{C2}(s) = \frac{\frac{6}{s}}{\frac{1}{s} + 1k + \frac{1}{2s}} \times \frac{1}{2s} = \frac{6}{s[2 + 2sk + 1]}$$

Voltage across the capacitor C2 in steady state,

$$V_{C2}(\infty) = \lim_{s\to 0} sV_{C2}(s) = \lim_{s\to 0} \frac{6}{[2 + 2sk + 1]} = \frac{6}{3}$$

$$V_{C2}(\infty) = 2 \text{ V}$$

∴ The charge on C_2 in steady state, $Q = C_2 V_{C2}(\infty)$

$$Q = (2)(2) = 4C$$

Alternate method :

$$Q_1(0^-) = 6C$$

$$V_{C_1}(0^-) = \frac{Q_1(0^-)}{C} = \frac{6}{1} = 6V$$

The initial voltage across the capacitor C_1 is 6V and capacitor C_2 is 0V i.e. $V_{C_2}\left(0^-\right) = 0V$

In steady state the voltage across two capacitors are equal i.e.

$$V_{C_1}(\infty) = V_{C_2}(\infty) = \frac{V_{C_1}\left(0^-\right)C_1 + V_{C_2}\left(0^-\right)C_2}{C_1 + C_2}$$

$$V_{C_1}(\infty) = V_{C_2}(\infty)$$

$$\Rightarrow \qquad \frac{(6\times 1)+0}{1+2} = 2V$$

The steady state voltage across capacitor C_2 is 2V

and change $Q_2 = C_2V_2 = 2 \times 2 = 4C$

End of Solution

Q.12 The total number of Boolean functions with distinct truth tables that can be defined over 3 Boolean variables is________.

Ans. (256)

The total number of Boolen function with distinct truth table will be for n Boolen variables

$\left(2^{2^n}\right)$ so for 3 Boolen variables = $\left(2^{2^3}\right) = 256$

End of Solution

Q.13 $\vec{a}, \vec{b}, \vec{c}$ are three orthogonal vectors, Given that $\vec{a} = \hat{i} + 2\hat{j} + 5\hat{k}$ and $\vec{b} = \hat{i} + 2\hat{j} - \hat{k}$, the vector $\vec{c}$ is parallel to

(a) $\hat{i} + 2\hat{j} + 3\hat{k}$
(b) $2\hat{i} + \hat{j}$
(c) $2\hat{i} - \hat{j}$
(d) $4\hat{k}$

Ans. **(c)**

$\bar{a}, \bar{b}, \bar{c}$ are mutually perpendicular

$\therefore$ $\bar{c}$ is parallel is $\bar{a} \times \bar{b}$

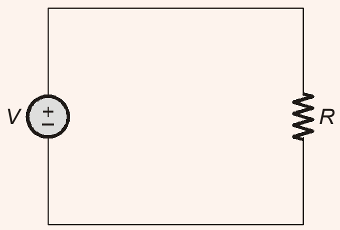
$$\bar{a} \times \bar{b} = \begin{vmatrix} \bar{i} & \bar{j} & \bar{k} \\ 1 & 2 & 5 \\ 1 & 2 & -1 \end{vmatrix} = \hat{i}(-12) - \hat{j}(-6) + 0\hat{k}$$

$$= -6(2\hat{i} - \hat{j})$$

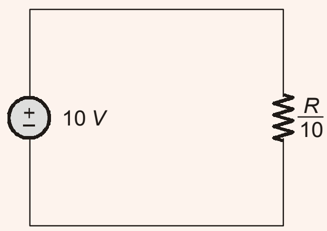
End of Solution

Q.14 Consider a circuit comprising only resistors with constant resistance and ideal independent DC voltage sources. If all the resistances are scaled down by a factor 10, and all source voltages are scaled up by a factor 10, the power dissipated in the circuit scales up by a factor of________.

Ans. **(1000)**



$$P = \frac{V^2}{R}$$



$$P' = \frac{(10V)^2}{R/10} = 1000\frac{V^2}{R}$$

$\therefore$ $P' = 1000P$

$\therefore$ Power dissipated scales up by a factor of 1000.

End of Solution

Q.15 If each of the values of inductance, capacitance and resistance of a series LCR circuit are doubled, the Q-factor of the circuit would

(a) reduce by a factor $\sqrt{2}$
(b) reduce by a factor 2
(c) increase by a factor $\sqrt{2}$
(d) increase by a factor 2

Ans. (b)

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

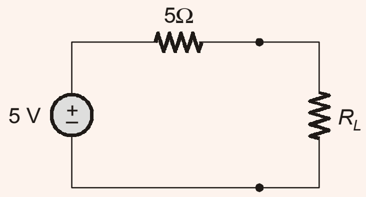
and as R, L and C are doubled.

$$\therefore \quad Q' = \frac{1}{2R}\sqrt{\frac{2L}{2C}} = \frac{1}{2}\left[\frac{1}{R}\sqrt{\frac{L}{C}}\right]$$

$$Q' = \frac{1}{2}Q$$

End of Solution

Q.16 In the circuit shown below, maximum power is transferred to the load resistance R_L, when R_L = ____________Ω.



Ans. (5)

According to maximum power transfer theorem, the maximum power will be transferred to the load when,

$$R_L = R_S$$

$$\therefore \quad R_L = 5\ \Omega$$

End of Solution

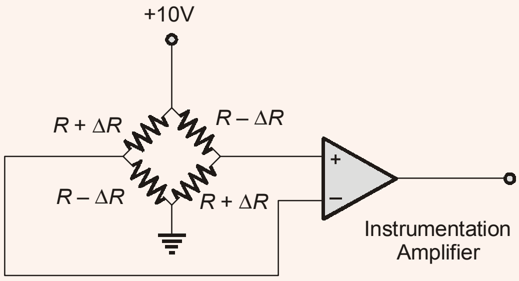
Q.17 Thermocouples measure temperature based on

(a) Photoelectric effect
(b) Seebeck effect
(c) Hall effect
(d) Thermal expansion

Ans. (b)

End of Solution

Q.18 Four strain gauges in a Wheatstone bridge configuration are connected to an instrumentation amplifier as shown in the figure. From the choices given below, the preferred value for the common mode rejection ratio (CMRR) of the amplifier, in dB, would be



(a) –20
(b) 0
(c) 3
(d) 100

Ans. (d)

End of Solution

Q.19 The output $y(t)$ of a system is related to its input $x(t)$ as

$$y(t) = \int_0^t x(\tau - 2)d\tau$$

where, $x(t) = 0$ and $y(t) = 0$ for $t \le 0$. The transfer function of the system is

(a) $\frac{1}{s}$
(b) $\frac{(1-e^{-2s})}{s}$
(c) $\frac{e^{-2s}}{s}$
(d) $\frac{1}{s} - e^{-2s}$

Ans. (c)

Put $x(t) = \delta(t)$

$$y(t) = h(t) = \int_0^t \delta(\tau - 2)dz = u(t-2)$$

So, $H(s) = \frac{e^{-2s}}{s}$

Alternatively,

$$Y(t) = \int_0^t x(\tau - 2)d\tau$$

$$Y(s) = \frac{1}{s} \times (s) \cdot e^{-2s}$$

$$\therefore \quad \frac{Y(s)}{X(s)} = \frac{e^{-2s}}{s}$$

End of Solution

Q.20 A pitot-static tube is used to estimate the velocity of an incompressible fluid of density 1 kg/m^3. If the pressure difference measured by the tube is 200 N/m^2, the velocity of the fluid, assuming the pitot-tube coefficient to be 1.0, is_______m/s.

Ans. (20)

Given that,

Density of the fluid, ρ = 1 kg/m^3

If the pressure difference measured, Δp = 200 N/m^2

The velocity of the fluid measured by pitot static tube is

$$v = \sqrt{\frac{2\Delta p}{\rho}} = \sqrt{\frac{2 \times 200}{1}} = 20 \text{ m/s}$$

End of Solution

Q.21 An 8-bit weighted resistor digital-to-analog converter (DAC) has the smallest resistance of 500 Ω. The largest resistance has a value___________kΩ.

Ans. (64)

In general, in a binary weighted resistor DAC, the relationship between LSB and MSB resistance is given as :

LSB Resistance = (2^{n-1}) MSB resistance where, n is the number of bits in the DAC.

Given, $n = 8$

$$\text{smallest resistance} = 500\ \Omega$$

$$\text{MSB resistance} = 500\ \Omega$$

$$\therefore \quad \text{LSB resistance} = (2^{8-1}) \times 500\Omega = 128 \times 500\Omega = 64000\Omega = 64\ \text{k}\Omega$$

End of Solution

Q.22 The input x[n] and output $y[n]$ of a discrete-time system are related as $y[n] = \alpha y[n-1] + x[n]$. The condition on α for which the system is Bounded-Input Bounded-Output (BIBO) stable is

(a) $|\alpha| < 1$

(b) $|\alpha| = 1$

(c) $|\alpha| > 1$

(d) $|\alpha| < \frac{3}{2}$

Ans. (a)

Here, $H(z) = \frac{1}{1-\alpha z^{-1}}; |z| > |\alpha|$

For system to be stable,

$$|\alpha| < 1$$

Therefore, option (a) is correct.

End of Solution

Q.23 A signal $\cos(2\pi f_m t)$ modulates a carrier $\cos(2\pi f_c t)$ using the double-sideband-with carrier (DSBWC) scheme to yield a modulated signal $\cos(2\pi f_c t) + 0.3\cos(2\pi f_m t)\cos(2\pi f_c t)$. The modulation index is__________.(Answer should be rounded off to one decimal place).

Ans. (0.3)

Double sideband with carrier signal is given by

$$s(t) = \cos(2\pi f_c t) + 0.3\cos(2\pi f_m t)\cos(2\pi f_c t)$$

$$= [1 + 0.3\cos(2\pi f_m t)]\cos 2\pi f_c t$$

Comparing with standard amplitude modulated signal

$$s(t) = A_c[1 + \mu\cos 2\pi f_m t]\cos 2\pi f_c t$$

$$\mu = 0.3$$

End of Solution

Q.24 In a cascade control system, the closed loop transfer function of the inner loop may be assumed to have a single time-constant τ_1. Similarly, the closed loop transfer function of the outer loop may be assumed to have a single time-constant τ_2. The desired relationship between τ_1 and τ_2 in a well-designed control system is

(a) τ_1 is much less than τ_2
(b) τ_1 is equal to τ_2
(c) τ_1 is much greater than τ_2
(d) τ_1 is independent of τ_2

Ans. (a)

In a Cascade control system, inner loop should function fast compared to the outerloop. Infact it is the basic characteristic of cascade control startergy.

Generally speed of response of loop is inversely propertional to time constant of the transfer function.

So, time constant of inner loop τ_1 should be less compared to the time constant of outer loop τ_2. Option (a) is correct answer.

End of Solution

Q.25 A 3 × 3 matrix has eigen values 1, 2 and 5. The determinant of the matrix is________.

Ans. (10)

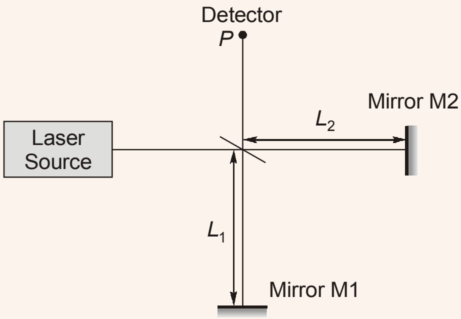
Product of eigen values $= |A|$

$= (1)\ (2)\ (5) = 10$

End of Solution

Q.26 - Q.55 Carry Two Mark each.

Q.26 Consider a Michelson interferometer as shown in the figure below. When the wavelength of the laser light source is switched from 400 nanometer to 500 nanometer, it is observed that the intensity measured at the output port P goes from a minimum to a maximum. This observation is possible when the smallest path difference between the two arms of the interferometer is____nanometer.



Ans. (1000)

As per the question the optical path difference in both the cases (400 nm or 500 nm) should be same but for 400 nm wavelength we should get distructive interference whereas for 500 nm wavelength we should get constructive interference.

∴ For constructive intereference optical path difference $(2x) = n\lambda_c$

For distructive interference optical path difference $(2x) = \dfrac{(2m+1)\lambda_D}{2}$

As per question,

$$n\lambda_c = \frac{(2m+1)\lambda_D}{2}$$

$$n(500) = \frac{(2m+1)\,400}{2}$$

∴ For $n = 2$ or $m = 2$ condition satisfied

∴ Optical path difference

$$2x = n\lambda$$
$$= 2(500\text{ nm})$$
$$= 1000\text{ nm}$$

End of Solution

Q.27 The dynamics of the state $\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$ of a system is governed by the differential equation

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 2 \\ -3 & -4 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 20 \\ 10 \end{bmatrix}$$

Given that the initial state is $\begin{bmatrix} 0 \\ 0 \end{bmatrix}$, the steady state value of $\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$ is

(a) $\begin{bmatrix} -30 \\ -40 \end{bmatrix}$ (b) $\begin{bmatrix} -20 \\ -10 \end{bmatrix}$

(c) $\begin{bmatrix} 5 \\ -15 \end{bmatrix}$ (d) $\begin{bmatrix} 50 \\ -35 \end{bmatrix}$

Ans. (d)

$$X(s) = \phi(s)\cdot x(0) + \phi(s)\cdot B\cdot U(s)$$

where, $\phi(s) = (sI - A)^{-1}$ Given $x(0) = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$

$\therefore$ $X(s) = \phi(s)\cdot B\cdot U(s)$

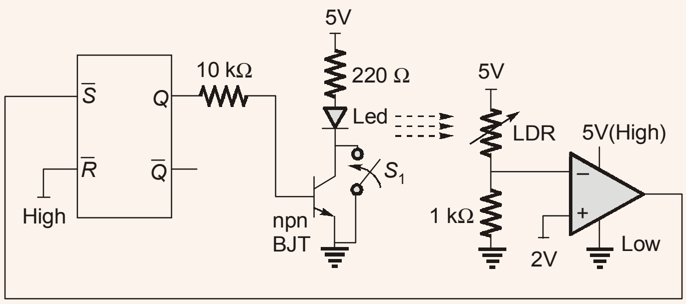
$$= \frac{1}{(s-1)(s+4)+6}\cdot\begin{bmatrix} 20(s+4)+20 \\ -60+10(s-1) \end{bmatrix}$$

Steady-state value of $X(t)$ for step input is

$$X(\infty) = \lim_{s\to 0} s\,X(s) = \begin{bmatrix} 50 \\ -35 \end{bmatrix}$$

End of Solution

Q.28 In the circuit below, the light dependent resistor (LDR) receives light from the LED. The LDR has resistances of 5 kΩ and 500 Ω under dark and illuminated conditions, respectively. The LED is OFF at time $t < 0$. At time $t = 0$ s, the switch S_1 is closed for 1 ms and then kept open thereafter. Assuming zero propagation delay in the devices, the LED



(a) turns ON when S_1 is closed and remains ON after S_1 is opened
(b) turns ON when S_1 is closed and turns OFF after S_1 is opened
(c) turns ON when S_1 is closed and toggles periodically from ON to OFF after S_1 is opened
(d) remains OFF when S_1 is closed and continues to remain OFF after S_1 is opened

Ans. (a)

When switch S_1 is closed, a conducting path will be formed from V_{cc} to ground irrespective of the operating condtion of the BJT. So, LED turns ON.

In this situation, LDR will have a resistance of 500 Ω. Voltage at the inverting terminal of the op-amp is,

$$V^- = \frac{1000}{1000+500} \times 5V = 3.33\text{V}$$

$$V^+ = 2\text{V}$$

$$V^- > V^+$$

$$\Rightarrow \quad V_{out} = 0 \text{ V (logic – LOW)}$$

So, $\bar{S}$ will be at logic - LOW at $\bar{R}$ will be at logic -HIGH. It pulses Q to logic-HIGH, which causs to flow some current into the base terminal of the BJT.

When swithc S_1 is opened after 1 ms:

Now, let us assume that LED is in OFF state. To check the validity of this assumption, we have to check whether current is flowing into the base terminal of the BJT.

When LED is in OFF state, LDR will have a resistance of 5 kΩ.

$$V^- = \frac{1}{1+5} \times 5V = 0.83\text{V}$$

$$V^+ = 2\text{V}$$

$$V^- < V^+$$

$$\Rightarrow \quad V_{out} = 5 \text{ V (logic – HIGH)}$$

So, $\bar{S}$ will be at logic - HIGH at $\bar{R}$ will be at logic -HIGH. It pulses Q to be in previous state (i.e., logic -HIGH). This makes the transistor to be in ON state and in turn LED will be in ON state.

So, our assumption is wrong, i.e., the LED will not be in OFF state after S_1 is opened. Hence, LED will be in ON state both during the switch S_1 is closed and after it is opened.

End of Solution

Q.29 In a control system with unity gain feedback, the transfer function of the loop-gain function is $L(s) = \frac{9e^{-0.1s}}{s}$. The phase margin of the loop-gain function $L(s)$ is______degrees.

Ans. (38.43)

$$G(s) = \frac{9e^{-0.1s}}{s}$$

$$PM = 180° + \left[-90° - 0.1\omega \times \frac{180°}{\pi}\right]_{\omega=\omega_{gc}}$$

$$\omega_{gc} = 9 \text{ r/s}$$

$$\therefore \quad \text{Phase margin} = 38.43°$$

End of Solution

Q.30 The curve $y = f(x)$ is such that the tangent to the curve at every point (x, y) has a Y-axis intercept c, given by $c = -y$. Then $f(x)$ is proportional to

(a) x^{-1}
(b) x^2
(c) x^3
(d) x^4

Ans. (b)

$$y = mx + c$$

$$y = \frac{dy}{dx}x + c \qquad \text{(given that Y intercept is } -y\text{)}$$

$$y = \frac{dy}{dx}x - y$$

$$\partial y = \frac{dy}{dx}x$$

$$\frac{dy}{\partial y} = \frac{dx}{x}$$

$$\Rightarrow \quad \frac{1}{2}\ln y = \ln x + \ln C$$

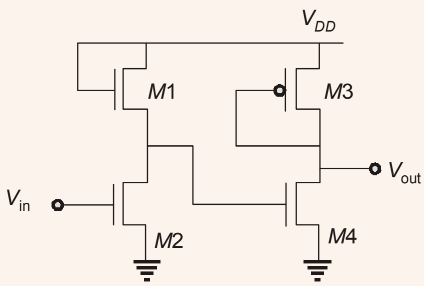
$$\ln y^{1/2} = \ln(xC)$$

$$y = x^2c^2$$

$$\therefore \quad y \propto x^2$$

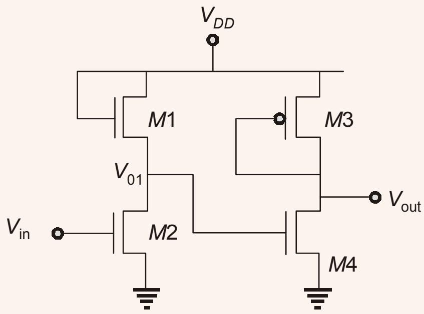
End of Solution

Q.31 A voltage amplifier is constructed using enhancement mode MOSFETs labeled M_1, M_2, M_3 and M_4 in the figure below. M_1, M_2 and M_4 are n-channel MOSFETs and M_3 is a p-channel MOSFET. All MOSFETs operate in saturation mode and channel length modulation can be ignored. The low frequency, small signal input and output voltages are v_{in} and v_{out} respectively and the dc power supply voltage is V_{DD}. All n-channel MOSFETs have identical transconductance g_{mn} while the p-channel MOSFET has transconductance g_{mp}. The expressions for the low frequency small signal voltage gain v_{out}/v_{in} is



(a) $\frac{-g_{mn}}{g_{mp}}$
(b) $-g_{mn}(g_{mn} + g_{mp})^{-1}$
(c) $\frac{+g_{mn}}{g_{mp}}$
(d) $g_{mn}(g_{mn} + g_{mp})^{-1}$

Ans. (c)



$$V_{01} = A_x V_{in} = -g_{mn} \times \frac{1}{g_{mn}} \times V_{in} = -V_{in}$$

$$V_0 = A_y V_{01} = -g_{mn} \times \frac{1}{g_{mp}} \times V_{01}$$

$$= -g_{mn} \times \frac{1}{g_{mp}} \times (-V_{in}) = +\frac{g_{mn}}{g_{mp}} \times V_{in}$$

$$\frac{V_0}{V_{in}} = \frac{g_{mn}}{g_{mp}}$$

End of Solution

Q.32 The forward path transfer function $L(s)$ of the control system shown in figure (a) has the asymptotic Bode plot shown in figure (b). If the disturbance $d(t)$ is given by $d(t) = 0.1 \sin(\omega t)$, where $\omega = 5$ rad/s, the steady-state amplitude of the output y(t) is

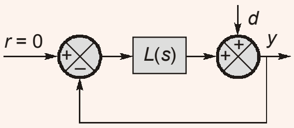


Figure (a)

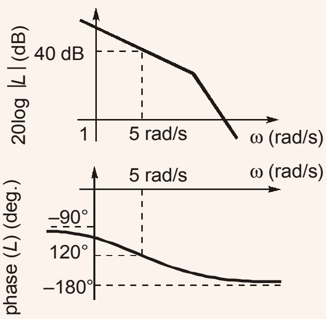


Figure (a)

(a) 1.00×10^{-3}
(b) 2.50×10^{-3}
(c) 5.00×10^{-3}
(d) 10.00×10^{-3}

Ans. (a)

$$\frac{Y(s)}{D(s)} = \frac{1}{1+L(s)}$$

$$\left|\frac{Y(j\omega)}{D(j\omega)}\right|_{\omega=5} = \frac{1}{\sqrt{1+(100)^2}} \simeq \frac{1}{100}$$

$\therefore$ Steady-state amplitude of output $= 0.1 \times \frac{1}{100} = 1.00 \times 10^{-3}$

End of Solution

Q.33 A complex function $f(z) = u(x, y) + iv(x, y)$ and its complex conjugate, $f^*(z) = u(x, y) - iv(x, y)$ are both analytic in the entire complex plane, where $z = x + iy$ and $i = \sqrt{-1}$. The function f is then given by

(a) $f(z) = x + iy$
(b) $f(z) = x^2 - y^2 + i2xy$
(c) $f(z) =$ constant
(d) $f(z) = x^2 + y^2$

Ans. (c)

$$f(z) = u + iv$$
$$f^*(z) = u - iv$$

Both are analytic when $f(z)$ is constant.

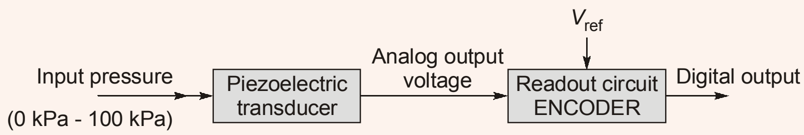
End of Solution

Q.34 A Piezoelectric transducer with sensitivity of 30 mV/kPa is intended to be used in the range of 0 kPa to 100 kPa. The readout circuit has peak noise amplitude of 0.3 mV arid measured signals over the full pressure range are encoded with 10 bits. The smallest pressure that produces a non-zero output, in units of Pa, is approximately

(a) 10
(b) 100
(c) 240
(d) 300

Ans. (b)

The overal block diagram of the above measurement system is given by

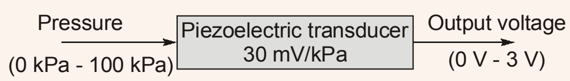


- Generally, encoder is a setup/device, which converts Analog voltage Signal into Digital code.
- According to the question, readout circuit has encoder of 10 bits. This means the resolution of encoder is given by

$$\frac{V_{ref}}{2^n - 1} \qquad \text{... (i)}$$

[Where 'n' represent number of bits]

- Piezoelectric transducer converts the input pressure to voltage by follows.



- The output voltage of Piezoelectric transducer is the input Analog voltage to Readout/Encoder circuit.
- To cover full pressure range,

V_{ref} = Maximum output voltage of Piezoelectric transducer + Peak noise amplitude

$$V_{ref} = 3 \text{ V} + 0.3 \text{ mV} = 3.0003 \text{ V} \qquad \text{... (ii)}$$

So, from equation (i) and (ii)

$$\text{Resolution of encoder} = \frac{3.0003}{2^{10} - 1} = 0.00293 \text{ V}$$

- The minimum input voltage, the readout requires is 0.00293 V. To get non zero output voltage, Piezoelectric transducer should provide minimum output voltage of 0.00293 V.
- As we already knows that Piezoelectric transducer converts
  1 kPa → 30 mV.
  ? ← 0.00293 V
  The minimum pressure that can produce non zero output voltage

$$= \frac{0.00293 \times 1 \times 10^3}{30 \times 10^{-3}} = 100 \text{ Pa}$$

End of Solution

Q.35 The frequency response of a digital filter H(ω) has the following characteristics
Passband : $0.95 \le |H(\omega)| \le 1.05$ for $0 \le \omega \le 0.3\pi$ and
Stopband : $0 \le |H(\omega)| \le 0.005$ for $0.4\pi \le \omega \le \pi$,
where ω is the normalized angular frequency in rad/sample. If the analog upper cut off frequency for the passband of the above digital filter is to be 1.2 kHz, then the sampling frequency should be________kHz.

Ans. (8)

$$\omega_P = 0.3\ \pi$$
$$\omega_S = 0.4\ \pi$$
$$F_P = 1.2 \text{ kHz}$$

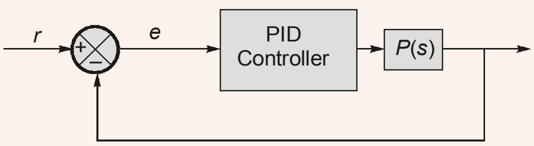
Since, $$\omega_P = \frac{2\pi F_P}{F_T}$$

So, sampling frequency,

$$F_T = \frac{2\pi F_P}{\omega_P}$$
$$= \frac{2\pi \times 1.2\text{kHz}}{0.3\pi} = 8 \text{ kHz}$$

End of Solution

Q.36 In the control system shown in the figure below, a reference signal $r(t) = t^2$ is applied at time $t = 0$. The control system employs a PID controller $C(s) = K_p + \frac{K_I}{s} + K_D s$ and the plant has a transfer function $P(s) = \frac{3}{s}$. If $K_p = 10$, $K_I = 1$ and $K_D = 2$, the steady state value of e is



(a) 0
(b) $\frac{2}{3}$
(c) 1
(d) ∞

Ans. (b)

$$\frac{E(s)}{R(s)} = \frac{1}{1+[(PID)(P)]}$$

$$= \frac{s^2}{3\left[s^2 + K_P s + K_i + K_D s^2\right]}$$

∴ Steady-state value of E is

$$E(\infty) = \lim_{s\to 0} sE(s)$$

$$= \lim_{S\to 0} s \cdot \frac{s^2}{3\left[s^2 + K_P s + K_i + K_D s^2\right]} \times \frac{2}{s^3}$$

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

End of Solution

Q.37 The function $p(x)$ is given by $p(x) = \dfrac{A}{x^{\mu}}$ where A and μ are constants with $\mu > 1$ and $1 \le x < \infty$ and $p(x) = 0$ for $-\infty < x < 1$. For $p(x)$ to be a probability density function, the value of A should be equal to

(a) $\mu - 1$

(b) $\mu + 1$

(c) $\dfrac{1}{(\mu - 1)}$

(d) $\dfrac{1}{(\mu + 1)}$

Ans. (a)

$$\int_{-\infty}^{\infty} f(x)\,dx = 1$$

$$\int_{-\infty}^{1} f(x)\,dx + \int_{1}^{\infty} f(x)\,dx = 1$$

$$0 + \int_{1}^{\infty} \frac{A}{x^{\mu}}\,dx = 1$$

$$A\left(\frac{x^{-\mu+1}}{-\mu+1}\right)\Bigg|_{1}^{\infty} = 1$$

$$\frac{A(0-1)}{1-\mu} = 1$$

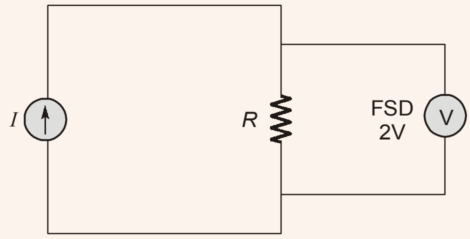
$$A = \mu - 1$$

End of Solution

Q.38 A resistance-meter has five measurement range-settings between 200 Ω and 2 MΩ in multiples of 10. The meter measures resistance of a device by measuring a full-range voltage of 2 V across the device by passing an appropriate constant current for each range-setting. If a device having a resistance value in the range 8 kΩ to 12 kΩ and a maximum power rating of 100 μW is to be measured safely with this metter, the choice for range-setting on the meter for best resolution in measurement, in kΩ, is

(a) 2
(b) 20
(c) 200
(d) 2000

Ans. (c)



Possible ranges
200 Ω
2 kΩ
20 kΩ
200 kΩ
2 MΩ

Resistance to be measured ⇒ 8 kΩ to 12 kΩ

So, minumum range should be 20 kΩ.

With 20 kΩ range:

$$I = \frac{2V}{20k\Omega} = \frac{1}{10}\text{mA}$$

$$P_{max} = I^2R_{max} = \left(\frac{1}{10}\times10^{-3}\right)^2 \times 12\times10^3 \text{ W} = 120\ \mu\text{W} > 100\ \mu\text{W}$$

With 200 kΩ range:

$$I = \frac{2V}{200k\Omega} = \frac{1}{100}\text{mA}$$

$$P_{max} = I^2R_{max} = \left(\frac{1}{100}\times10^{-3}\right)^2 \times 12\times10^3 \text{ W}$$

$$= 1.2\ \mu\text{W}$$

End of Solution

Q.39 The transfer function relating the input $x(t)$ to the output $y(t)$ of a system is given by $G(s) = \frac{1}{(s+3)}$. A unit-step input is applied to the system at time $t = 0$. Assuming that $y(0) = 3$, the value of $y(t)$ at time $t = 1$ is________(Answer should be rounded off to two decimal places).

Ans. (0.4659)

The solution can be split into two portions

$$y(t) = y_s(t) + y_n(t)$$

where, $y_s(t)$ = steady state response, $y_n(t)$ = normal response

∴ To calculate the steady-state response, we will assume initial input to be zero.

$$\therefore \quad G(s) = \frac{1}{s+3}$$

$$\therefore \quad \frac{Y(s)}{X(s)} = \frac{1}{s+3}$$

$$(s+3)Y(s) = X(s)$$
$$sY(s) + 3Y(s) = X(s)$$

Now, given input is a step response

$$\therefore \quad sY(s) + 3Y(s) = \frac{1}{s}$$

$$\therefore \quad Y(s) = \frac{1}{s(s+3)}$$

$$Y(s) = \frac{A}{s} + \frac{B}{s+3} = \frac{1/3}{s} + \frac{-1/3}{s+3}$$

Applying, inverse laplace transform, we get

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

Now, to calculate the natural respose, we assume that the input $x(t) = 0$

$$sy(s) - y(0) + 3y(s) = 0$$
$$(s+3)Y(s) = y(0)$$
$$y(s) = \frac{y(0)}{s+3}$$

Given $y(0) = 3$

$$\therefore \quad Y(s) = \frac{3}{s+3}$$

Taking the inverse laplace transform, we get

$$y_n(t) = 3e^{-3t}u(t)$$

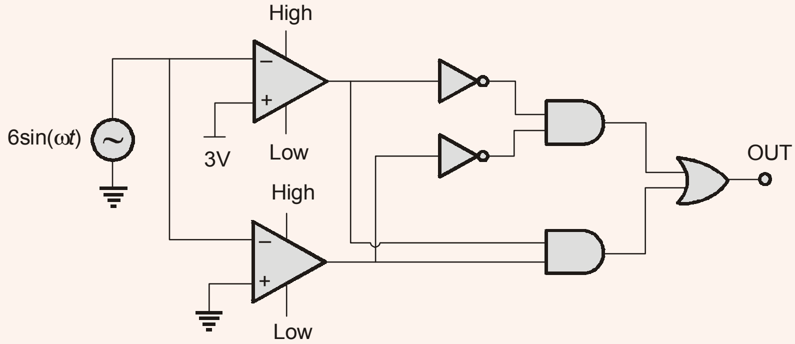
$\therefore$ Total response, $y(t) = y_s(t) + y_n(t)$

$$\therefore \quad y(t) = 3e^{-3t}u(t) + \frac{1}{3}u(t) - \frac{1}{3}e^{-3t}u(t)$$

$$\therefore \quad y(t) = 0.4659$$

End of Solution

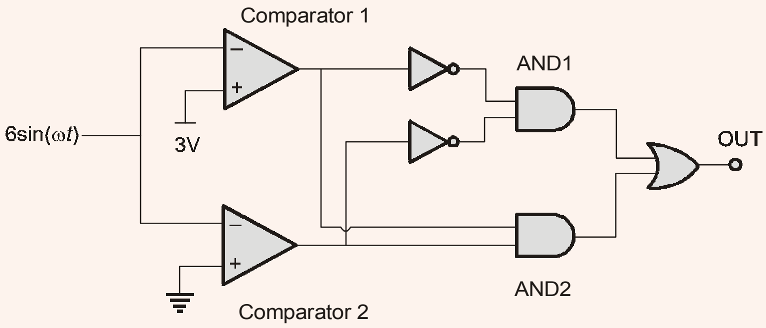
Q.40 In the circuit shown below, assume that the comparators are ideal and all components have zero propagation delay. In one period of the input signal $V_{in} = 6\sin(\omega t)$, the fraction of the time for which the output OUT is in logic state HIGH is

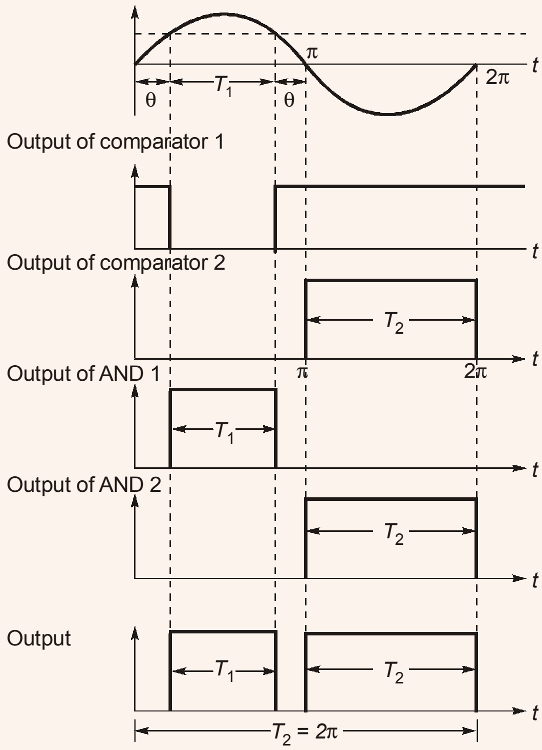


(a) $\frac{1}{12}$ (b) $\frac{1}{2}$

(c) $\frac{2}{3}$ (d) $\frac{5}{6}$

Ans. (d)





$$6\sin\theta = 3$$

$$\Rightarrow \quad \theta = \sin^{-1}\left(\frac{3}{6}\right) = \frac{\pi}{6}$$

$$T_1 = \pi - 2\theta$$

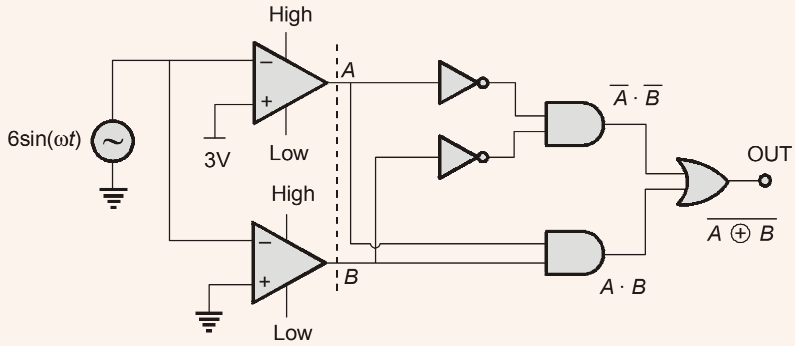
$$= \pi - \frac{2\pi}{6} = \frac{2\pi}{3}$$

$$T_2 = \pi$$

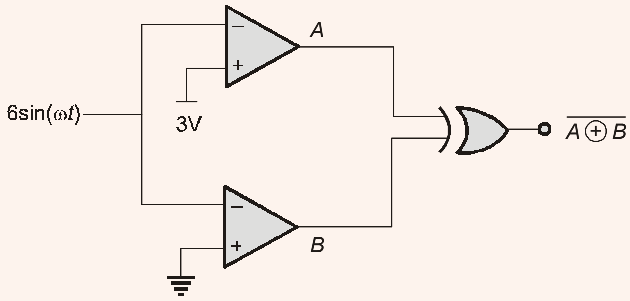
Fraction of time for which output is high $= \frac{T_1 + T_2}{T}$

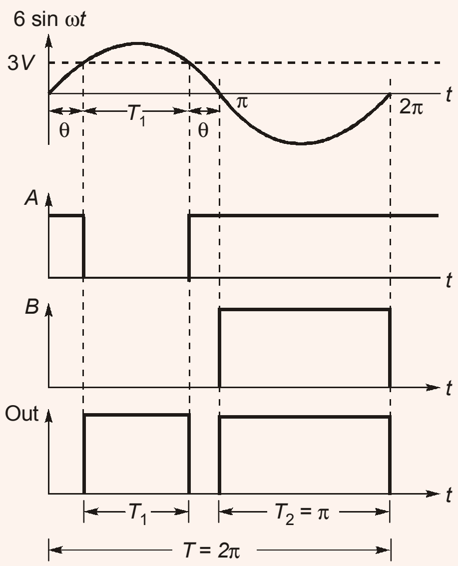
$$= \frac{\frac{2\pi}{3} + \pi}{2\pi} = \frac{5}{6}$$

Alternate method :



Above digital circuit behaves like XNOR gate.





$$6 \sin\theta = 3$$

$$\Rightarrow \qquad \theta = \sin^{-1}\left(\frac{3}{6}\right) = \frac{\pi}{6}$$

$$T_1 = \pi - 2\theta = \pi - \frac{2\pi}{6} = \frac{2\pi}{3}$$

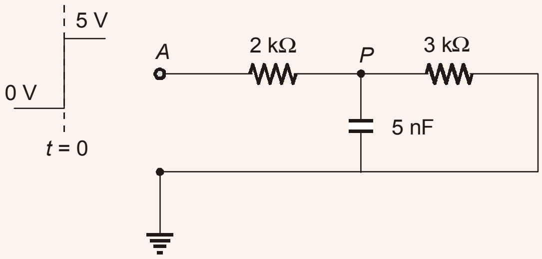
$$T_2 = \pi$$

Fraction of time for which output is high $= \dfrac{T_1 + T_2}{T}$

$$= \frac{\frac{2\pi}{3} + \pi}{2\pi} = \frac{5}{6}$$

End of Solution

Q.41 In the circuit shown below, a step input voltage of magnitude 5 V is applied at node A at time $t = 0$. If the capacitor has no charge for $t \le 0$, the voltage at node P at $t = 6$ μs is ___________V.



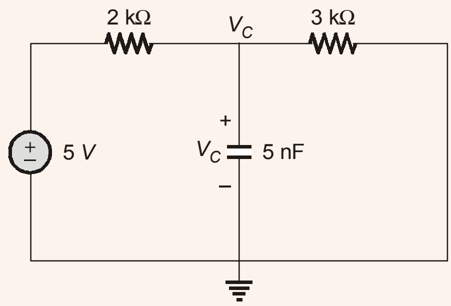
Ans. **(1.896)**

$$V_C(0^-) = 0 \text{ V}$$

As $V_C(0^+) = V_C(0^-)$

$\therefore$ $V_C(0^+) = 0$ V

For $t > 0$



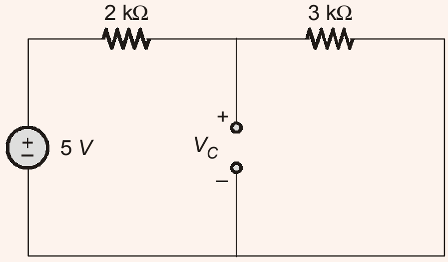
$$V_C(t) = V_C(\infty) + [V_C(0^+) - V_C(\infty)]\, e^{-t/\tau} \quad \text{... (i)}$$

$$\tau = R_{eq}.C$$

$$R_{eq} = 2k \parallel 3k = \frac{(2k)(3k)}{5k} = \frac{6}{5}\,\text{k}\Omega$$

$\therefore$ $$\tau = \left(\frac{6}{5}\text{k}\right)(5n) = 6 \times 10^{-6} \text{ sec}$$

At $t = \infty$,



$$V_C(\infty) = \frac{5}{2k+3k} \times 3k = 3\text{ V}$$

Using equation (i)

$$V_C(t) = 3 + [0-3]e^{-t/6\times10^{-6}}$$

∴ Voltage at node P at t = 6 μs,

$$V_C(6\,\mu s) = 3\left[1-e^{-6\times10^{-6}/6\times10^{-6}}\right] = 3\left[1-e^{-1}\right]$$

$$V_C(6\,\mu s) = 1.896\text{ V}$$

End of Solution

Q.42 The output of a continuous-time system $y(t)$ is related to its input $x(t)$ as $y(t) = x(t) + \frac{1}{2}x(t-1)$. If the Fourier transforms of $x(t)$ and $y(t)$ are $X(\omega)$ and $X(\omega)$ respectively and $|X(0)|^2 = 4$. the value of $|Y(0)|^2$ is ________.

Ans. (9)

$$y(t) = x(t) + \frac{1}{2}x(t-1)$$

Apply Fourier transform

$$Y(\omega) = X(\omega) + \frac{1}{2}e^{-j\omega}X(\omega)$$

$$|Y(\omega)| = |X(\omega)| + \frac{1}{2}|X(\omega)|$$

$$|Y(\omega)|^2 = |X(\omega)|^2 + \frac{1}{4}|X(\omega)|^2 + |X(\omega)|^2$$

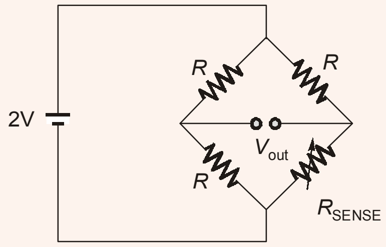
Put $\omega = 0$

$$|Y(0)|^2 = |X(0)|^2 + \frac{1}{4}|X(0)|^2 + |X(0)|^2$$

$$|Y(0)|^2 = 9$$

End of Solution

Q.43 Four identical resistive strain gauges with gauge factor of 2.0 are used in a Wheatstone bridge as shown in the figure below. Only one of the strain gauges R_{SENSE} changes its resistance due to strain. If the output voltage V_{out} is measured to be 1 mV, the magnitude of strain, in units of microstrain is



(a) 1
(b) 10
(c) 100
(d) 1000

Ans. (d)

The given resistance bridge is of Quarter bridge. So the output voltage of the bridge is

$$V_{OB} = \frac{V_s}{4} \times \frac{\Delta R}{R_0} \quad \text{...(1)}$$

In strain gauge, $$G_f = \frac{\left(\frac{\Delta R}{R_0}\right)}{\in} \quad \text{...(2)}$$

where, V_s = Supply voltage ΔR = change in resistance, R_o = Initial resistance of the gauge and $\in$ = strain,

From eq. (1) and (2),

$$V_{OB} = \frac{V_s}{4} \times G_f \in$$

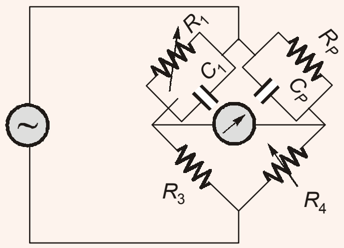
$$1 \times 10^{-3} = \frac{2}{4} \times 2 \times \in$$

$$\in = 1 \times 10^{-3} \text{ units} = 1000 \text{ micro strain}$$

So, option (d) is correct answer.

End of Solution

Q.44 The parallel resistance-capacitance bridge shown below has a standard capacitance value of C_1 = 0.1 μF and a resistance value of R_3 = 10 kΩ. The bridge is balanced at a supply frequency of 100 Hz for R_1 = 375 kΩ, R_3 = 10 kΩ and R_4 = 14.7 kΩ. The value of the dissipation factor $D = \frac{1}{(\omega R_p C_p)}$ of the parallel combination of C_p and R_p is________(Answer should be rounded off to Three decimal places).



Ans. (0.0424)

In the given bridge circuit,

$$Z_1 = \frac{R_1}{1+j\omega C_1 R_1}$$

$$Z_2 = \frac{R_P}{1+j\omega C_P R_P}$$

$$Z_3 = R_3$$

$$Z_4 = R_4$$

At balance condition,

$$Z_1 Z_4 = Z_2 Z_3$$

$$\frac{R_1 R_4}{1+j\omega C_1 R_1} = \frac{R_P R_3}{1+j\omega C_P R_P}$$

$$R_1 R_4 + j\omega C_P R_P R_1 R_4 = R_P R_3 + j\omega C_1 R_1 R_P R_3$$

Separately the real and imaging components

$$R_1 R_4 = R_P R_3 \text{ or } R_P = \frac{R_1 R_4}{R_3}$$

$$C_P R_4 = C_1 R_3$$

or $$C_P = \frac{C_1 R_3}{R_4}$$

Given, $$D = \frac{1}{\omega C_P R_P} = \frac{1}{\omega} \times \frac{R_4}{C_1 R_3} \times \frac{R_3}{R_1 R_4} = \frac{1}{\omega C_1 R_1}$$

Given, $$C_1 = 0.1 \times 10^{-6}\text{F}; \quad R_1 = 375 \times 10^3 \Omega$$

$$\omega = 2 \times \pi \times 100 = 628.318$$

$\therefore$ $$D = \frac{1}{628.318 \times 0.1 \times 10^{-6} \times 375 \times 10^3} = 0.0424$$

End of Solution

Q.45 A discrete-time signal $x[n] = e^{j\left(\frac{5\pi}{2}\right)n} + e^{j\left(\frac{\pi}{4}\right)n}$ is down-sampled to the signal $x_d[n]$ such that $x_d[n] = x[4n]$. The fundamental period of the down-sampled signal $x_d[n]$ is__________.

Ans. (6)

$$x(n) = e^{j(5\pi/3)n} + e^{j(\pi/4)n}$$

$$\omega_1 = \frac{5\pi}{3}$$

$$\omega_2 = \frac{\pi}{4}$$

GCD (ω_1, ω_2) $$\omega_0 = \frac{\pi}{12}$$

$$x_d(n) = x(4n)$$

Apply time scaling so,

$$\omega_d = 4\omega_0 = \frac{4\pi}{12} = \frac{\pi}{3}$$

$$\frac{\omega d}{2\pi} = \frac{m}{N}$$

$$\Rightarrow \quad \frac{\pi/3}{2\pi} = \frac{m}{N}$$

$$N = 6$$

End of Solution

Q.46 A 100 W light source emits uniformly in all directions. A photodetector having a circular active area whose diameter is 2 cm is placed 1 m away from the source, normal to the incident light. If the responsivity of the photodetector is 0.4 A/W, the photo-current generated in the detector, in units of mA, is

(a) 1 (b) 4

(c) 100 (d) 400

Ans. (a)

Intensity of light at photo detector $= \left(\frac{\text{Power}}{4\pi d^2}\right) W/m^2$

where d is distance in meters $= \frac{100}{4\pi(1)^2} = \frac{100}{4\pi} W/m^2$

Power received by photodetector = Intensity of light × Active area of photo detector

$$= \frac{100}{4\pi} \times \pi \times (0.01)^2 = \frac{1}{400} W$$

$$\text{Responsibility} = \frac{\text{Output current}}{\text{Power}}$$

Output current = Responsivity × Power

$$= \frac{1}{400} \times 0.4 = \frac{1}{1000} A = 1 \text{ mA}$$

Hence, answer (a)

End of Solution

Q.47 A pulsed laser emits rectangular pulses of width 1 nanosecond at a repetition rate of 1 kHz. If the average power output is 1 mW, the average power over a single pulse duration, in Watts, is

(a) 1 (b) 10

(c) 100 (d) 1000

Ans. (d)

Given that Laser emits rectangular pulse width of 1 nsec.

Repetition rate of 1 kHz.

If the average output power is 1 mW.

Energy of each pulse is given by

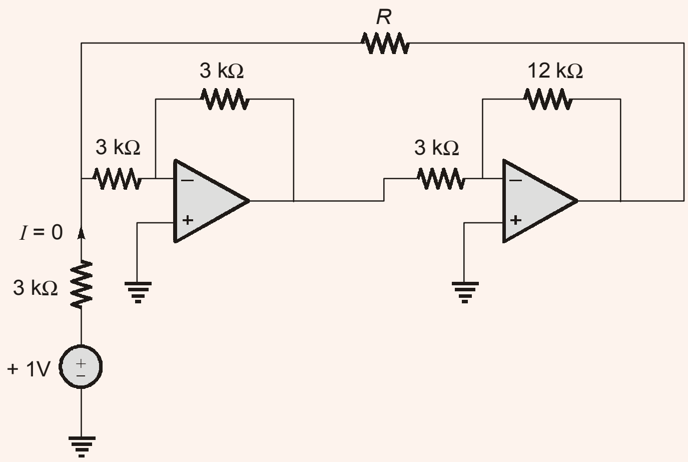
$$E = \frac{P_{av}}{R_{rate}} = \frac{1\times10^{-3}}{1\times10^{3}} = 1\times10^{-6} \text{ Joules}$$

Power of each pulse $P_{pulse} = \dfrac{E}{\text{Duration of pulse}}$

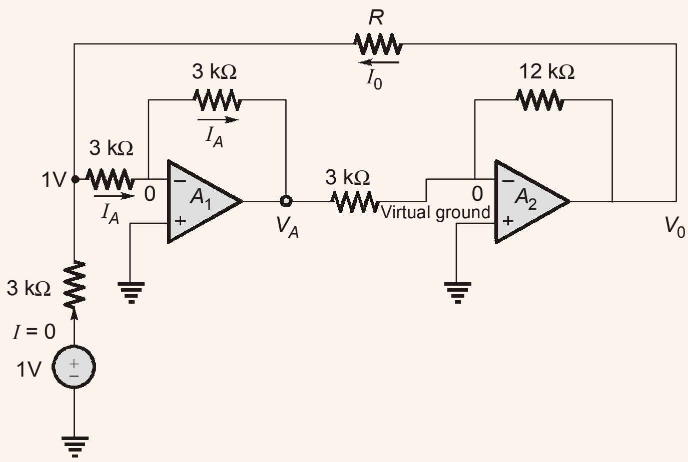
$$= \frac{1\times10^{-6}}{1\times10^{-9}} = 1000$$

End of Solution

Q.48 In the circuit shown below all OPAMPS are ideal. The current I = 0 A when the resistance R = ______kΩ.



Ans. (9)



Opamp A_1

KCLat V^-

$$\frac{1V - 0}{3k} = \frac{0 - V_A}{3k}$$

$$V_A = -1 \text{ V}$$

Opamp A_2

KCL at V^-

$$\frac{V_A - 0}{3k} = \frac{0 - V_0}{12k}$$

$$-\frac{1}{3k} = -\frac{V_0}{12k}$$

$$V_0 = 4 \text{ V}$$

KCL at 1 V

$$I_0 + I = I_A$$

$$I_0 = I_A = \frac{1V - 0}{3k} = \frac{1}{3}\text{mA}$$

$$R = \frac{V_0 - 1V}{I_0} = \frac{4V - 1V}{\frac{1}{3}\text{mA}} = \frac{3}{\frac{1}{3}\text{mA}} = 9\text{ k}\Omega$$

$$R = 9 \text{ k}\Omega$$

End of Solution

Q.49 In a microprocessor with a 16 bit address bus. the most significant address lines A15 to A12 are used to select a 4096 word memory unit, while lines A0 to A11 are used to address a particular word in the memory unit. If the 3 least significant lines of the address bus A0 to A2 are short-circuited to ground, the addressable number of words in the memory unit is__________.

Ans. **(512)**

Total address line = 16

3 lines grounded

4 lines for chip select

Remaining lines 9

2^9 = 512 words.

End of Solution

Q.50 $X = X_1X_0$ and $Y = Y_1Y_0$ are 2-bit binary numbers. The Boolean function S that satisfies the condition "If $X > Y$, then $S = 1$", in its minimized form, is

(a) $X_1Y_1 + X_0Y_0$

(b) $X_1\bar{Y}_1 + X_0\bar{Y}_0\bar{Y}_1 + X_0\bar{Y}_0X_1$

(c) $X_1\bar{Y}_1X_0\bar{Y}_0$

(d) $X_1\bar{Y}_1 + X_0\bar{Y}_0Y_1 + X_0\bar{Y}_0\bar{X}_1$

Ans. (b)

Given $X = X_1X_0$

and $Y = Y_1Y_0$

If $X > Y$

Then, $S = 1$

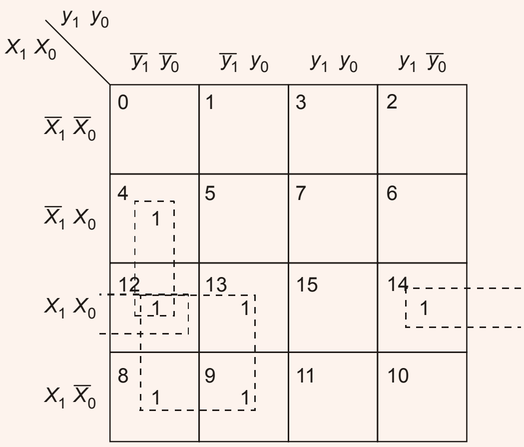
The truth table for S can be drawn as follows,

	X		y		
	X_1	X_0	y_1	y_0	S
0	0	0	0	0	0
1	0	0	0	1	0
2	0	0	1	0	0
3	0	0	1	1	0
4	0	1	0	0	1
5	0	1	0	1	0
6	0	1	1	0	0
7	0	1	1	1	0
8	1	0	0	0	1
9	1	0	0	1	1
10	1	0	1	0	0
11	1	0	1	1	0
12	1	1	0	0	1
13	1	1	0	1	1
14	1	1	1	0	1
15	1	1	1	1	0

The Boolean function S can be represented in the sum of minterms form as

$$S(X_1, X_0, Y_1, Y_0) = \Sigma(4, 8, 9, 12, 13, 14)$$

The above function can be simplified usking k-Map as follows :



$$S = X_1\bar{Y}_1 + X_0\bar{Y}_1\bar{Y}_0 + X_1X_0\bar{Y}_0$$

End of Solution

General Studies & Engineering Aptitude Batches for ESE 2020

(Preliminary Examination)

MADE EASY
India's Best Institute for IES, GATE & PSUs

Syllabus Covered

1. Current issues of national and international importance relating to social economic and industrial development.
2. Engineering Aptitude covering Logical reasoning and Analytical ability.
3. Engineering Mathematics and Numerical Analysis.
4. General Principles of Design, Drawing, Importance of Safety.
5. Standards and Quality practices in production, construction, maintenance and services.
6. Basic of Energy and Environment : Conservation, Environmental pollution and degradation, Climate Change, Environmental impact assessment.
7. Basic of Project Management.
8. Basics of Material Science and Engineering.
9. Information and Communication Technologies (ICT) based tools and their applications in Engineering such as networking, e-governance and technology based education.
10. Ethics and values in engineering profession.

Course Duration

Regular Batches : 2.5 months
Weekend Batches : 4 months

Timings

Regular : 6 to 7 days a week and 4-6 hours a day
Weekend : Sat, Sun & public holiday, 8 hours each day

Teaching Hours

250-300 hours

Batch Type	Commencing Dates	Venue	Timing
Regular Batch	20th Feb, 2019	Ghitorni (Delhi)	8:00 AM to 12:00 PM
Weekend Batch	24th Feb, 2019	Ghitorni (Delhi)	8:00 AM to 5:00 PM
Weekend Batch	24th Feb, 2019	Noida Centre	8:00 AM to 5:00 PM

Fee Structure

Non-MADE EASY Students	Ex. MADE EASY Students Enrolled in Postal, Rank Improvement, Mains, GS, GATE, GATE + ESE Batches
₹ 25,000 • GS & Engg Aptitude Books will be issued.	₹ 18,000 • GS & Engg Aptitude Books will NOT be issued. • Interested students can avail books by paying the fee of Rs. 2,000/-

Corporate office : 44-A/1, Kalu Sarai, New Delhi - 1100 16 ✆ 011-45124612, 9958995830

Noida office : D-28, Sector - 63, Noida, Uttar Pradesh - 201301 ✆ 0120-6524612, 08860378009

ADMISSION OPEN

Q.51 In a control system with unity gain feedback, the plant has the transfer function $P(s) = \frac{3}{s}$.

Assuming that a controller of the form $C(s) = \frac{K}{(s+p)}$ is used, where K is a positive constant, the value of p for which the root-locus of the closed-loop system passes through the points $-3 \pm j3\sqrt{3}$ where $j = \sqrt{-1}$, is

(a) 3
(b) $3\sqrt{3}$
(c) 6
(d) 9

Ans. (c)

$$\text{OLTF} = \frac{3k}{s(s+P)}$$

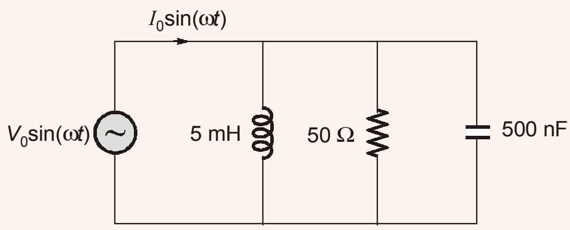
Given root locus passes through the point $-3 \pm j3\sqrt{3}$

$$\therefore \quad \angle G(s)H(s)_{s=-3+j3\sqrt{3}} = \pm 180^\circ$$

$$\therefore \quad P = 6$$

End of Solution

Q.52 In the circuit shown below, the angular frequency ω at which the current is in phase with the voltage is__________rad/s.



Ans. (20000)

At resonance the source voltage and source current will be in phase.

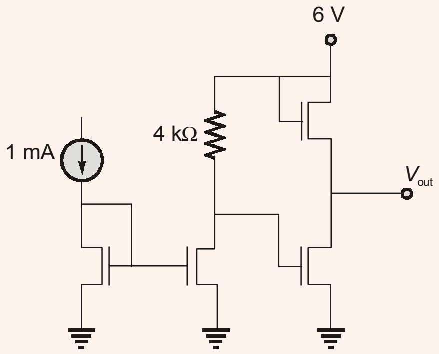
$$\therefore \quad \omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{5 \times 10^{-3} \times 500 \times 10^{-9}}} \text{ rad/sec}$$

$$= \frac{1}{\sqrt{25 \times 10^{-10}}} = \frac{100 \times 10^3}{5} = 20\text{ k}$$

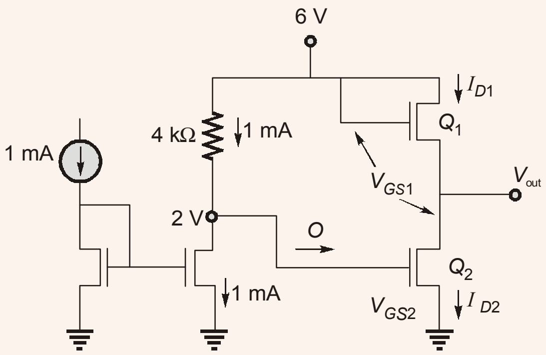
$$\omega = 20000 \text{ rad/sec}$$

End of Solution

Q.53 In the circuit shown below, all transistors are n-channel enhancement mode MOSFETs. They are identical and are biased to operate in saturation mode. Ignoring channel length modulation, the output voltage V_{out} is_________V.



Ans. (4)



Current mirror

Q_1 and Q_2 are in current saturation mode

$$-6+\left(1\times10^{-3}\times4\times10^{3}\right)+V_{GS_2} = 0$$

$$V_{GS_2} = 2V$$

$$I_{D_1} = I_{D_2}$$

$$\frac{1}{2}k_n\left(V_{GS_1}-V_T\right)^2 = \frac{1}{2}k_n\left(V_{GS_2}-V_T\right)^2$$

$$V_{GS_1} = V_{GS_2} = 2V$$

$$-6+V_{GS_1}+V_0 = 0$$

$$V_0 = 6-V_{GS_1}$$

$$V_0 = 6-2 = 4V$$

End of Solution

Q.54 A signal $x(t)$ has a bandwidth $2B$ about a carrier frequency of f_c = 2 GHz as shown in figure (a) below. In order to demodulate this signal, it is first mixed (multiplied) with a local oscillator of frequency f_{LO} = 1.5 GHz, and then passed through an ideal low-pass filter (LPF) with a cut-off frequency of 2.8 GHz. The output of the LPF is sent to a digitizer ADC with a sampling rate of 1.6 GHz as shown in figure (b) below. The maximum value of B so that the signal $x(t)$ can be reconstructed from its samples according to the Nyquist sampling theorem is________MHz.

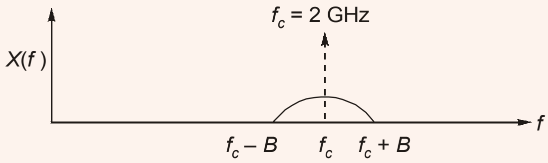


Figure (a)

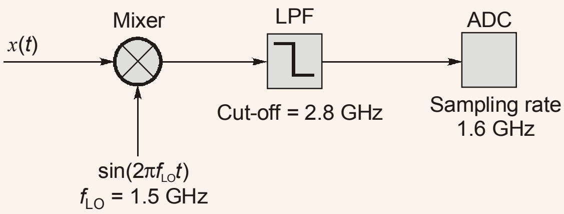
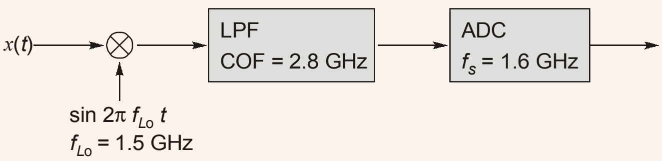
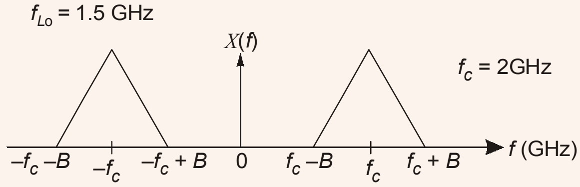


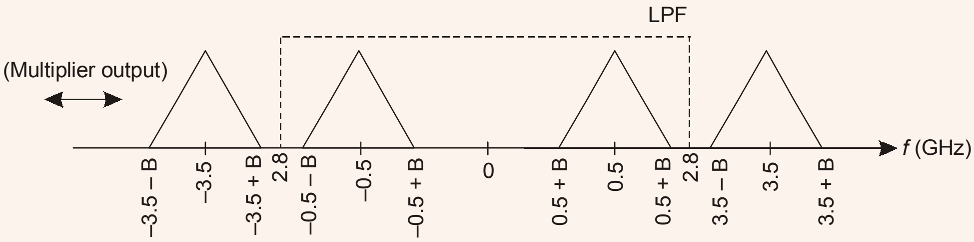
Figure (b)

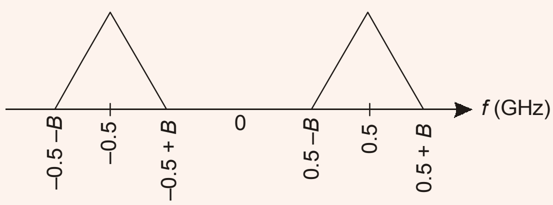
Ans. (300)





By multiplying with sinusoidal signal,
$X(f)$ shifted to right by f_{Lo} and left by f_{Lo}





$$\text{Nyquist rate} = 2 \times f_{max}$$
$$= 2\,[0.5 + B] = 1 + 2\,B$$

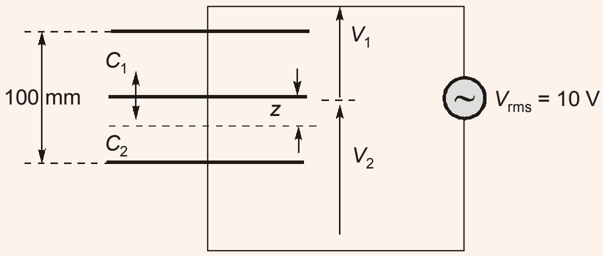
Given Sampling rate, f_s = 1.6 GHz

To recover original signal, $f_s \geq$ Nyquist rate

$$1.6 \text{ GHz} \geq 1 \text{ GHz} + 2B$$
$$2B \leq 0.6 \text{ GHz}$$
$$B = 0.3 \text{ GHz}$$
$$B_{max} = 0.3 \text{ GHz}$$
$$= 300 \text{ MHz}$$

End of Solution

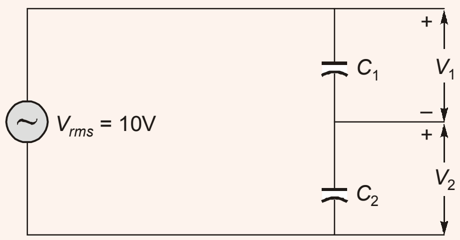
Q.55 A differential capacitive sensor with a distance between the extreme plates 100 mm is shown in figure below. The difference voltage $\Delta V = V_1 - V_2$, where V_1 and V_2 are the rms values, for a downward displacement of 10 mm of the intermediate plate from the central position, in volts, is



(a) 0.9
(b) 1.0
(c) 1.1
(d) 2

Ans. (d)

The given figure in the question can be redrawn as



$$V_0 = 10\left[\frac{\frac{\in A}{d-z} - \frac{\in A}{d+z}}{\frac{\in A}{d+z} + \frac{\in A}{d-z}}\right] = 10\left[\frac{d+z-d+z}{d+z+d-z}\right] = 10 \times \frac{z}{d}$$

$$= 10 \times \frac{10 \text{ mm}}{50 \text{ mm}} = 2\text{V}$$

So, option (d) is correct answer.

End of Solution

■■■■