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GATE – 2019

Questions with Detailed Solutions

INSTRUMENTATION ENGINEERING

All Queries related to **GATE- 2019** Solutions are to be sent to the following email address
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GENERAL APTITUDE

01. Some students were not involved in the strike.

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

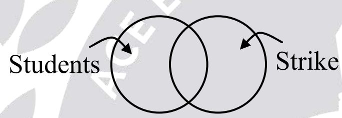
1. Some who were involved in the strike were students.
2. No students was involved in the strike.
3. At least one student was involved in the strike.
4. Some who were not involved in the strike were students.

(a) 1 and 2 (b) 3

(c) 4 (d) 2 and 3

01. Ans: (c)

Sol: From the given statement, the following venn-diagram can be formed



Some who were not involved in the strike were also students so, 4^{th} statement will be true logically.

$\therefore$ Hence, option (c) is correct.

End of Solution

02. Until Iran came along, India had never been _______ in kabaddi.

(a) defeated (b) defeating

(c) defeat (d) defeatist

02. Ans: (a)

Sol: It is in the passive voice so had + been +V_3 form.

03. 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

03. Ans: (c)

Sol: As no two odd or even numbers are next to each other and second number from left is exactly half of the left most number, the only possibility is

Left most 10 5 _ __ __ __

Now, middle number is twice the right most number, thus __

Left most 10 5 4 __ 2 Right most

Therefore, 7 must be the 2nd number from the right

Left most 10 5 4 7 2 Right most

End of Solution

04. 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

04. Ans: (c)

Sol: Volume of cone = $\frac{1}{3}\pi r^2 h$

As per question, radius and height both increase by 10%

We know that, change in volume = Successive change of increase in radius and height.

$\therefore$ Successive change of 10%, 10% and 10% = successive of21% and 10% = 33.1%

Thus, change in volume = 33.1%

End of Solution

05. The fishermen, __________ the flood victims owed their lives, were rewarded by the government.

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

05. Ans: (c)

Sol: The fishermen, to whom the flood victims owed their lives, were rewarded by the government.

Objective case of who.

End of Solution

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

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

06. Ans: (b)

Sol: Relative speed of both trains 80 + 100 = 180 km/hr

Initially they are separated by distance = 540 km

$\therefore$ Time taken to meet = $\frac{540}{180} = 3\text{hrs}$

Thus, they meet 3hrs after 7AM i.e., 10AM.

End of Solution

07. 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

07. Ans: (c)

Sol: As per the data given

→ "dhrupad" is associated with "baani"

→ "gayaki" is associated with "vocal"

→ "baaj" is associated with "instrumental"

→ "gharana" is associated with "lineage"

Thus, baaj, institution is not correct

Hence (c) is correct.

End of Solution

08. "I read somewhere that in ancient times the prestige of a kingdom 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

08. Ans: (d)

Sol: Head-hunter refers to the number of heads he could gather.

09. In a country of 1400 million population, 70% own mobile phones. Among the mobile phone owners, only 294 million access the internet. Among these 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

09. Ans: (a)

Sol: Population: 1400 million

Population with mobile phones = $\dfrac{70}{100} \times 1400 = 980\,\text{million}$

Population with mobile phones who access internet = 294 million (given)

Population with mobile phones who access internet and buy goods from e-commerce portals = $\dfrac{50}{100} \times 294 = 147\,\text{million}$

$\therefore$ Percentage of buyers in country = $\dfrac{147}{1400} \times 100 = 10.5\%$

End of Solution

10. 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 schemes to bring them on par with fixed deposit interest rates.

Which 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 sometime takes into consideration the demands of banking institutions before reducing the interest rates on small saving schemes.

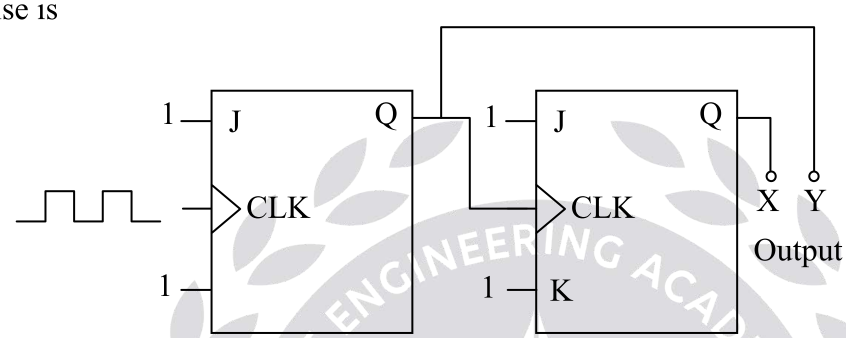
(d) A reduction in interest rates on small saving schemes follow only after a reduction in repo by the Reserve Bank of India.

10. Ans: (d)

Sol: The word 'some times' is not possible as you find indications like 'since the last one year' and the word 'finally' means almost coming to the conclusion. In addition to that the government comes in after RBI reduces repo rate.

INSTRUMENTATION ENGINEERING

01. 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 outputs is X = 0and 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

01. Ans: (d)

Sol: It is a 2-bit asynchronous down counter, which counts XY = 00, 11, 10, 01, 11,

Thus, the value of XY just before the arrival of the second circuit pulse is $\Rightarrow$ X = 1, Y = 1

End of Solution

02. 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

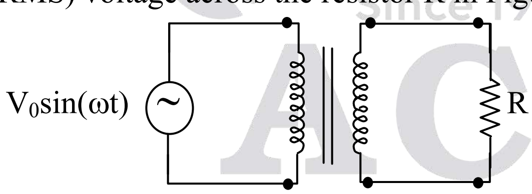


Figure (a)

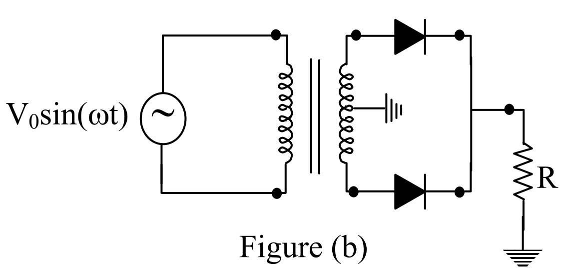
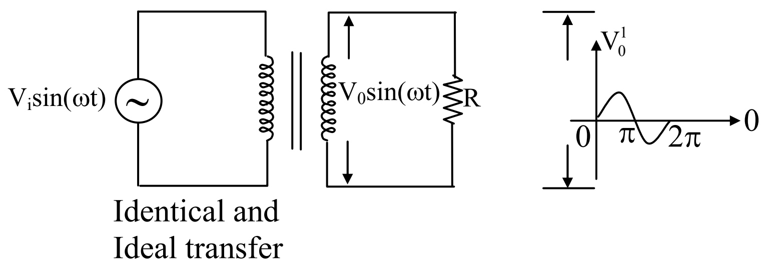


Figure (b)

(a) $\sqrt{2}:1$ (b) $2:1$ (c) $2\sqrt{2}:1$ (d) 4:1

02. Ans: (b)

Sol: For fig-(a)



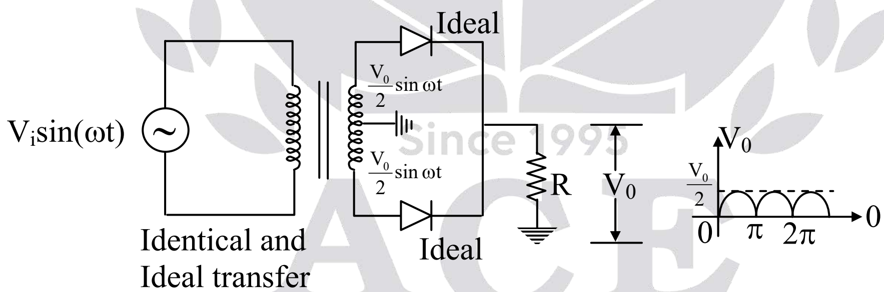
Here $V_0^1 = V_0 \sin\omega t (or) V_0^1 = V_0 \sin\theta (0 < \theta < 2\pi)$

$$\therefore (V_{rms})_{o/p} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} V_0^2 d\theta}$$

$$= \sqrt{\frac{1}{2\pi}\int_0^{2\pi} V_0^2 \sin^2\theta d\theta}$$

$$= \sqrt{\frac{V_0^2}{2\pi}\int_0^{2\pi}\frac{1-\cos 2\theta}{\theta}d\theta} = \frac{V_0}{\sqrt{2}}$$

for fig-b



$$\therefore (V_{rms})_{o/p} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi}\left(\frac{V_0}{2}\right)^2 \sin^2\theta d\theta}$$

$$= \frac{V_0}{2\sqrt{2}}$$

$$\therefore (V_{rms})_{o/p} = \frac{V_0}{2\sqrt{2}}$$

or

$\therefore\ V_0 = V_0 \sin\omega t$ (for +Ve half)

$= -V_0 \sin\omega t$ (for –Ve half cycle)

$\therefore$ The ratio of r.m.s of voltage fig-a to fig-b is

$$\frac{(V_{rms})_{fig-a}}{(V_{rms})_{fig-b}} = \frac{\frac{V_0}{\sqrt{2}}}{\frac{V_0}{2\sqrt{2}}} = \frac{2}{1} = 2:1$$

$\therefore$ option 'b' is correct one

End of Solution

03. 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

03. Ans: (a)

Sol: $\rightarrow$ LED operates in forward bias to glow light

$\rightarrow$ Photo diode operates in reverse bias to detect light

$\rightarrow$ zener diode operates in reverse bias to act as voltage regulator

End of Solution

04. 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 $t \leq 0$. The transfer function of the system is

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

04. Ans: (c)

Sol: If the input is impulse $\delta(t)$, then the o/p is called I.R h(t)

$$\therefore h(t) = \int_0^t \delta(t-2)d\tau = u(t-2)$$

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

05. 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)

05. Ans: 0.3

Sol: Given modulated signal

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

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

$s_{Am}(t) = A_c\,[1 + \mu\cos(2\pi f_m t)]\,\cos(2\pi f_c t)$

$\mu = 0.3$

End of Solution

06. If each of the values of inductance 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

06. Ans: (b)

Sol: $Q_s = \frac{1}{R}\sqrt{\frac{L}{C}}$

Each is doubled

$$Q_s = \frac{1}{2R}\sqrt{\frac{2L}{2C}} = \frac{1}{2}\left[\frac{1}{R}\sqrt{\frac{L}{C}}\right]$$

So, Q-factor reduce by factor '2'

End of Solution

07. 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) $|\alpha| < 3/2$

07. Ans: (a)

Sol: BIBO stable

$\therefore y(n) = \alpha y(n-1) + x(n)$

$\therefore |\alpha| < 1$

End of Solution

08. 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.

08. Ans: (c)

Sol: Zero dispersion wavelength or zero dispersion point the measured wavelength in a optical fiber where material dispersion and wavelength dispersion cancel each other.

End of Solution

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

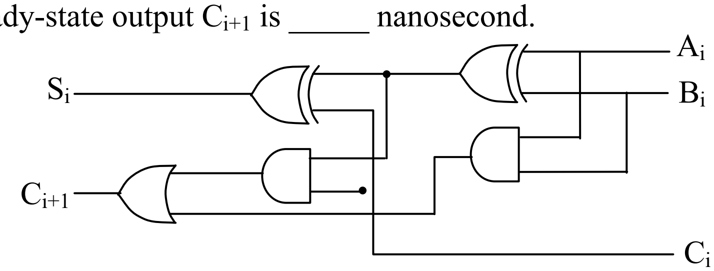
09. Ans: 0.13

Sol: $d_1 = 0.12\text{V}$, $d_2 = 0.05\text{mA}$

$$R = \sqrt{d_1^2 + d_2^2} = \sqrt{(0.12)^2 + (0.05)^2} = \sqrt{0.0144 + 0.0025} = \sqrt{0.0169} = 0.13$$

End of Solution

10. The figure below shows that 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. Assuming 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.



10. Ans: 4

Sol: A and B inputs are available at t = 0 and state throughout process.

The max time taken for input 'C_i' to produce C_{i+1} output is $= t_{AND} + t_{OR} = 2 + 2 = 4$

11. 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

11. Ans: 20m/sec

Sol: $S_{fluid} = 1 kg/m^3$

$\Delta p = 200 N/m^2$

$V_f = ?$

$C_V = 1.0$

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

End of Solution

12. $\vec{a},\vec{b},\vec{c}$ 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) $4\hat{k}$

12. Ans: (c)

Sol: Given $\vec{a} = i+2j+5k$

$\vec{b} = i+2j-k$

The vectors $\vec{a},\vec{b},\vec{c}$ are orthogonal

$\Rightarrow \vec{a}.\vec{b} = 0 \quad \vec{b}.\vec{c} = 0 \;,\; \vec{a}.\vec{c} = 0$

$\therefore$ Option (c) satisfies

$\therefore \vec{c} = 2i - j$

Clearly $\vec{a}.\vec{c} = (i + 2j + 5k) . (2i - j) = 2 - 2 = 0$

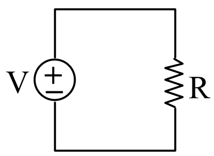
$\vec{b}.\vec{c} = (i + 2j - k) . (2i - j) = 2 - 2 = 0$

End of Solution

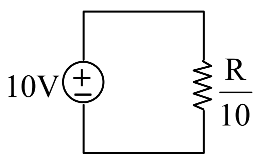
13. Consider a circuit comprising only resistors with constant resistance and ideal independent DC voltage sources. If all the resistances are scaled down by a factor 10, and all source voltages are scaled up by a factor 10, the power dissipated in the circuit scales up by a factor of ______ .

13. Ans: 1000

Sol:



$$P_{abs} = \frac{V^2}{R}$$



$$P_{abs} = \frac{(10V)^2}{R/10} = 1000\left[\frac{V^2}{R}\right]$$

So, answer is 1000.

End of Solution

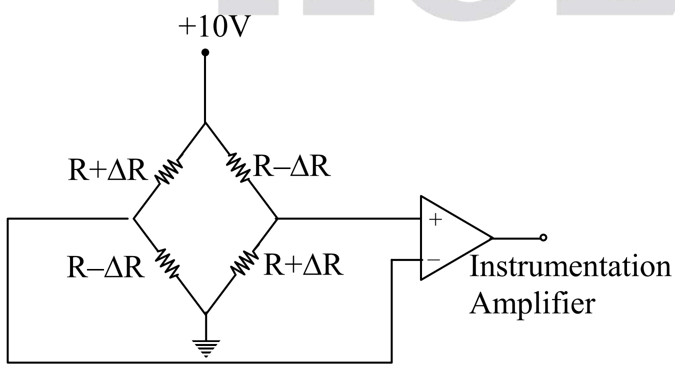
14. The total number of Boolean function with distinct truth-tables that can be defined over 3 Boolean variables is _____ .

14. Ans: 256

Sol: Total No of Boolean functions over 3 Boolean variables is $= 2^{2^3} = 2^8 = 256$

End of Solution

15. 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

15. Ans: (d)

Sol: CMRR for an ideal instrumentation Amplifier is infinite, CMRR $= \left|\frac{A_d}{A_{CM}}\right|$

$$CMRR_{dB} = 20\log\left|\frac{A_d}{A_{CM}}\right|$$

Option (a) cannot be the answer because of negative dB

Option (b) is also wrong as the $A_d \neq A_{CM}$

Option (c) is also wrong as $A_d \neq 1.5\ A_{CM}$

Option (d) could be the answer.

End of Solution

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

(a) –1 (b) 0 (c) 1 (d) ∞

16. Ans: (b)

Sol: Given $\vec{A} = \nabla u$

We know that curl $(\vec{A})$ = curl $(\nabla u) = 0$. For any scalar function

End of Solution

17. In a cascade control system, the 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

17. Ans: (a)

Sol: In a cascade (or) master-slave control system, the slave loop (inner loop) must be faster than the master loop (outer loop)

For proper control, slave loop should be atleast 3 times faster than the master loop (outer loop)

$$\tau_{\text{outer Loop}} \geq 3\tau_{\text{inner Loop}}$$

$$\tau_2 \geq 3\tau_1$$

Hence we can say inner loop time constant is much lower than the outer loop time constant

18. A 3×3 matrix has eigen values 1, 2 and 5. The determinant of the matrix is _______ .

18. Ans: 10

Sol: Given that eigen values of 3 × 3 matrix are 1 , 2 , 5

We know that det = product of eigen values = 1 × 2 × 5 = 10

End of Solution

19. 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

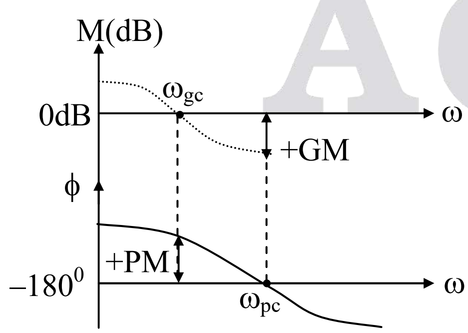
(d) stable

19. Ans: (d)

Sol: $$L(s) = \frac{k}{(s+1)(s+2)(s+3)}$$

Gain crossover frequency < Phase crossover frequency

$\omega_{gc} < \omega_{pc}$



$\omega_{pc} > \omega_{gc}$ system is stable because, in this case GM and PM is positive.

20. 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) 4/15 (b) 7/16

(c) 1/2 (d) 8/15

20. Ans: (a)

Sol: Given that Box contains 8 Red Balls and 8 Green Balls

Two Balls are drawn successively without replacement.

Probablity of first ball is red and second ball is green

$$= \frac{8}{16} \times \frac{8}{15} = \frac{4}{15}$$

End of Solution

21. Thermocouple measure temperature based on

(a) Photoelectric effect

(b) Seebeck effect

(c) Hall effect

(d) Thermal expansion

21. Ans: (b)

Sol: Thermocouple is a active transducer works on the principle of seebeck effect

End of Solution

22. An 8-bit weighted resistor digital-to-analog converter (DAC) has the smallest resistance of 500 Ω. The largest resistance has a value ______ kΩ.

22. Ans: 64

Sol: In a N-Bit Binary weighted resistor

Digital to Analog converter,

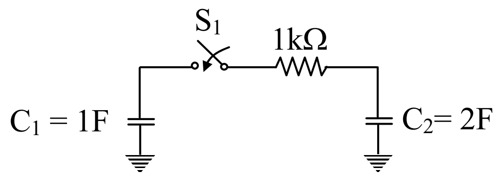
the largest value of resistance $= 2^{N-1}R$

$$= 2^{(8-1)}, (500)$$

$$= 128 \times 0.5$$

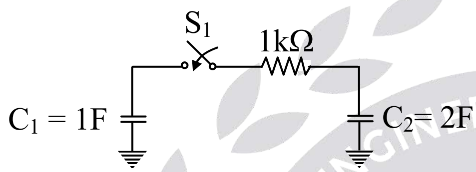
$$= 64 k\Omega$$

23. In the circuit shown below, initially the switch S_1 is open, the capacitor C_1 has a charge of 6 coulomb, and the capacitor C_2 has 0 coulomb. After S_1 is closed, the charge on C_2 in steady state is _____ coulomb.



23. Ans: 4

Sol:



By law of conservation of charge

$q_T = q_1 + q_2$

$C_T V_T = C_1 V_1 + C_2 V_2$

Where $C_1 = 1F$, $V_1 = 6V$ and $q_1 = 6C$

$C_2 = 2F$, $V_2 = 0V$ and $q_2 = 0$

Parallel

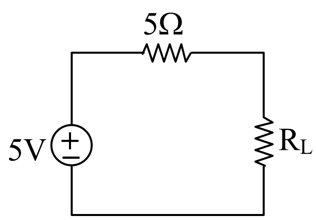
$[1 + 2]\ V_T = (1)(6) + (2)(0)$

$V_T = 2\text{volts}$

So, $q_2 = C_2 V_T = (2)(2) = 4C$

End of Solution

24. In the circuit shown below, maximum power is transferred to the load resistance R_L, when R_L = ________ Ω.



24. Ans: 5

Sol: P_{max} occurs if $R_L = R_S$

So, $R_L = 5\Omega$

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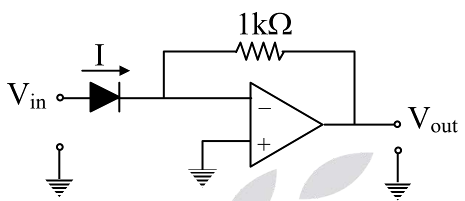
AIR 2 CHIRAG SINGLA ME
AIR 3 RAMESH KAMULLA E&T
AIR 3 SRIJAN VARMA EE
AIR 3 PRAVEEN KUMAR CE
AIR 3 MAYUR PATIL ME
AIR 4 JAPJIT SINGH E&T
AIR 4 ANKIT GARG EE
AIR 4 AMIT KUMAR ME
AIR 5 NARENDRA KUMAR E&T
AIR 5 KARTHIK KOTTURU EE
AIR 5 RISHABH DUTT CE
AIR 5 VITTHAL PANDEY ME
AIR 6 KUMUD JINDAL E&T
AIR 6 RATIPALLI NAGESWAR EE
AIR 7 KARTIKEYA DUTTA E&T
AIR 7 TEKCHAND DESHWAL EE
AIR 7 ROHIT KUMAR CE
AIR 8 SURYASH GAUTAM E&T
AIR 8 RAVI TEJA MANNE EE
AIR 8 VIJAYA NANDAN CE
AIR 8 ROHIT BANSAL ME
AIR 9 SHANAVAS CP E&T
AIR 9 SOUVIK DEB ROY EE
AIR 9 ROOPESH MITTAL CE
AIR 10 PRATHAMESH E&T
AIR 10 MILAN KRISHNA EE
AIR 10 SRICHAND POONIYA CE
TOTAL SELECTIONS in Top 10 34
E&T TOP 10 10
EE TOP 10 10
CE TOP 10 8
ME TOP 10 6
and many more...

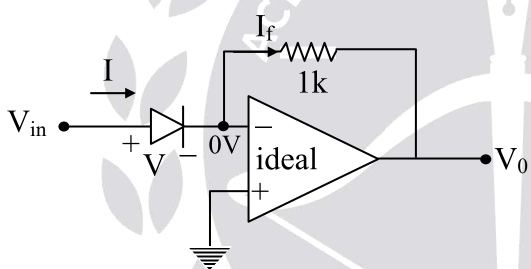
25. In the circuit shown below, the input voltage V_{in} is positive. The current (I) - voltage (V) characteristics of the diode can be assumed to be $I = I_0 e^{V/V_T}$ under the forward bias condition, where V_T is the thermal voltage and I_0 is the reverse saturation current. Assuming an ideal op-amp,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



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

25. Ans: (c)

Sol:



given that $I = I_0\, e^{\frac{V}{V_T}} \rightarrow (1)$

from the circuit

$I = I_f \rightarrow (2)$

$$I_f = \frac{0 - V_0}{1k} = I = I_0 e^{\frac{V}{V_T}}$$

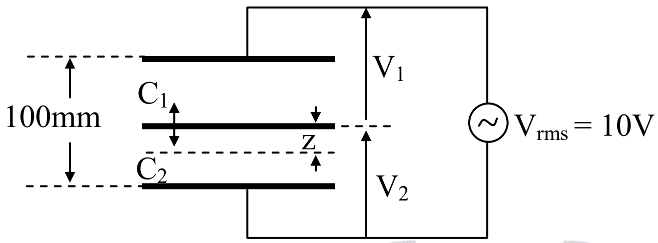
$$\therefore V_0 = (-1k) I_0 e^{\frac{V}{V_T}}$$

$$\therefore V_0 = 0 - (1k) I_0 e \frac{V_{in}}{V_T}$$

Hence $V_0 \alpha\, e^{\frac{V_{in}}{V_T}}$

∴ option 'c' is correct one

26. A differential capacitive sensor with a distance between the extreme plates 100mm 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 10mm of the intermediate plate from the central position, in volts, is



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

26. Ans: (d)

Sol: $\Delta V = V_1 - V_2$

$$\Delta V = \frac{x}{d}E$$

$$= \frac{10mm}{50mm} \times 10$$

$$= 2V$$

Detailed solution

$$C_1 = \frac{\varepsilon A}{d+x}, \qquad C_2 = \frac{\varepsilon A}{d-x}$$

$$E_1 = \frac{C_2}{C_1 + C_2}.E \qquad E_2 = \frac{C_1.E}{C_1 + C_2}$$

$$E_1 = \frac{\frac{\varepsilon A}{d-x}}{\left(\frac{\varepsilon A}{d-x}\right) + \left(\frac{\varepsilon A}{d+x}\right)} \qquad E_2 = \frac{\frac{\varepsilon A}{d+x}}{\left(\frac{\varepsilon A}{d-x}\right) + \left(\frac{\varepsilon A}{d+x}\right)}$$

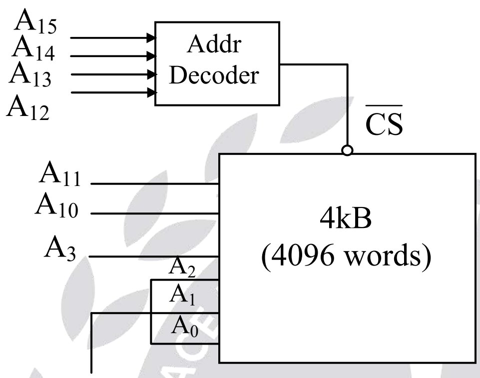
$$E_1 = \frac{d+x}{2d}.E \qquad E_2 = \frac{d-x}{2d}$$

$$\Delta V = E_1 - E_2 = E\frac{x}{d} = 2V$$

27. In a microprocessor with a 16 bit address buss, 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 ______ .

27. Ans: 512

Sol:



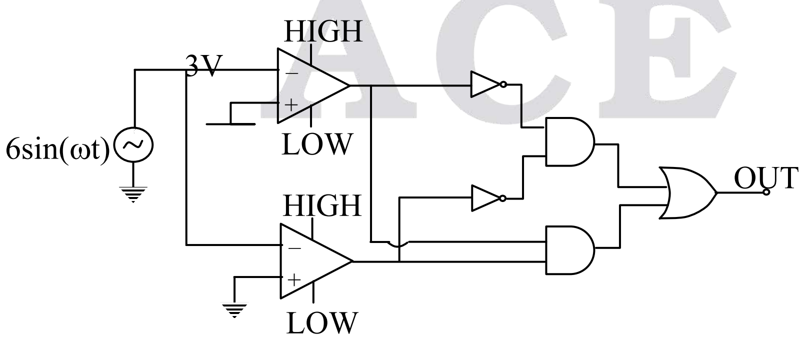
As A_2, A_1, $A_0 = 0$

The Number of Address lines available for main internal Access is = 12 – 3 = 9

the number of words addressable = $2^9 = 512$

End of Solution

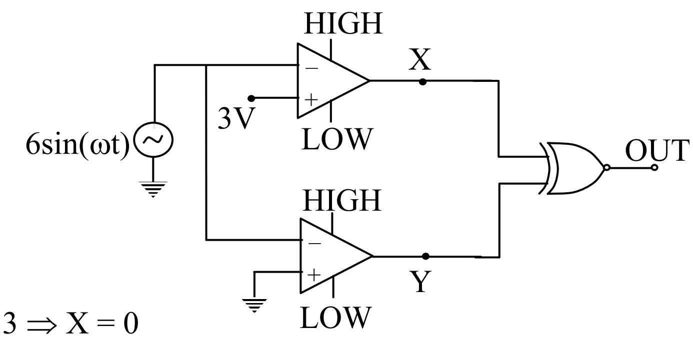
28. In the circuit shown below, assume that the comparators are ideal and all components have zero propagation delay. In one period of the input signal $V_{in} = 6\sin(\omega t)$, the fraction of the time for which the output OUT is in logic state HIGH is



(a) 1/12
(b) 1/2
(c) 2/3
(d) 5/6

28. Ans: (d)

Sol:

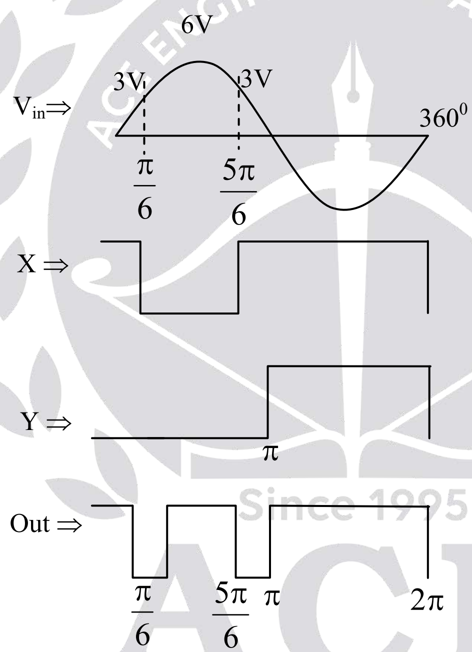


$V_{in} \geq 3 \Rightarrow X = 0$

$V_{in} < 3 \Rightarrow X = 1$

$V_{in} \geq 0 \Rightarrow Y = 0$

$V_{in} < 0 \Rightarrow Y = 1$



The output is high for $\left(\frac{\pi}{6} \text{to} \frac{5\pi}{6}\right)$ and $(\pi \text{ to } 2\pi)$

$$= \left(\frac{5\pi}{6} - \frac{\pi}{6}\right) + (2\pi - \pi)$$

$$= \frac{4\pi}{6} + \pi = \frac{10\pi}{6}$$

$$\text{Ratio} \Rightarrow \frac{10\frac{\pi}{6}}{2\pi} = \frac{5}{6}$$

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

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

29. Ans: (b)

Sol: Resolution of encoder = $\dfrac{V_{ref}}{2^n - 1}$

$1\text{kPa} \Rightarrow 30\text{mV}$

$100\text{kPa} \Rightarrow 3000 \text{ mV} = 3\text{V}$

Noise of readout circuit = 3V + 0.3mV

$V_{ref} = 3.0003\text{V}$

Resolution = $\dfrac{3.0003}{2^{10}-1} = \dfrac{3.0003}{1023} = 0.00293 \text{ V}$

Smallest readout by system = 0.00293V

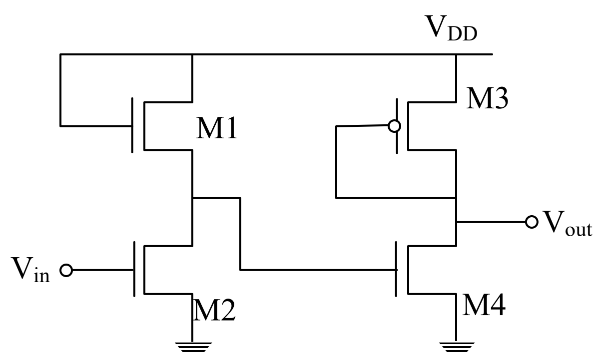
$1\text{kPa} \rightarrow 30\text{mV}$

$0.00293\text{V} \times \dfrac{1\text{kPa}}{30\text{mV}} \leftarrow 0.00293\text{V}$

Resolution from i/p side = $97.666\text{Pa} \approx 100\text{Pa}$

End of Solution

30. A voltage amplifier is constructed using enhancement mode MOSFETs labelled M1, M2, M3 and M4 in the figure below. M1, M2 and M4 are n-channel MOSFETs and M3 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 voltage 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

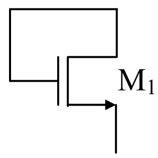


(a) $-g_{mn} / g_{mp}$ (b) $-g_{mn}(g_{mn} + g_{mp})^{-1}$

(c) $+g_{mn} / g_{mp}$ (d) $g_{mn}(g_{mn} + g_{mp})^{-1}$

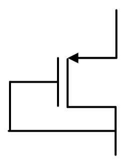
30. Ans: (c)

Sol:



$\equiv$

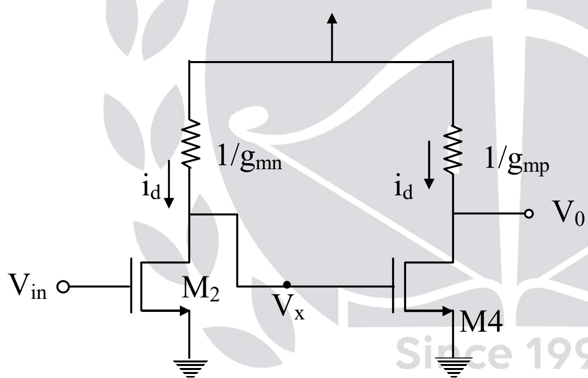
$\frac{1}{g_{mn}} \| r_{on} \approx \frac{1}{g_{mn}}$



$\equiv$

$\frac{1}{g_{mp}} \| r_{op} \approx \frac{1}{g_{mp}}$

AC Equivalent

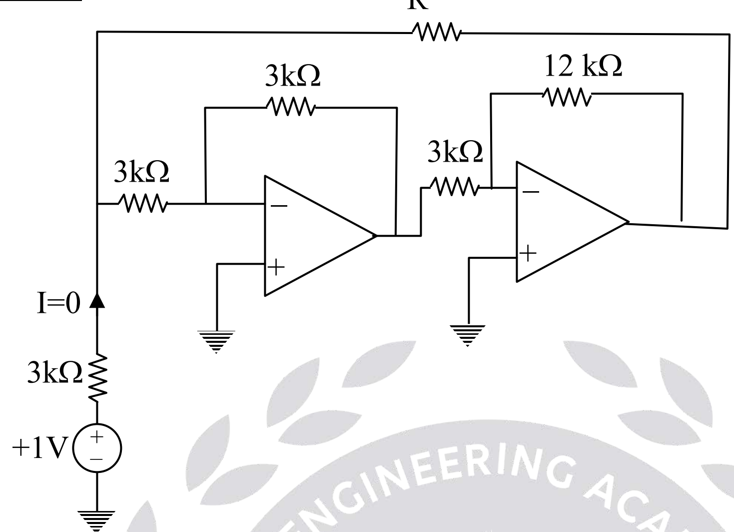


$$\frac{V_0}{V_{in}} = \frac{V_0}{V_x}\frac{V_x}{V_{in}} = \frac{-i_d\left[\frac{1}{g_{mp}}\right]}{V_gS_2} \cdot \frac{-i_d\left[\frac{1}{g_{mn}}\right]}{V_gS_2}$$

$$= \frac{-\frac{1}{g_{mn}}}{\frac{1}{g_{mp}}} \cdot \frac{-\frac{1}{g_{mp}}}{\frac{1}{g_{mn}}}$$

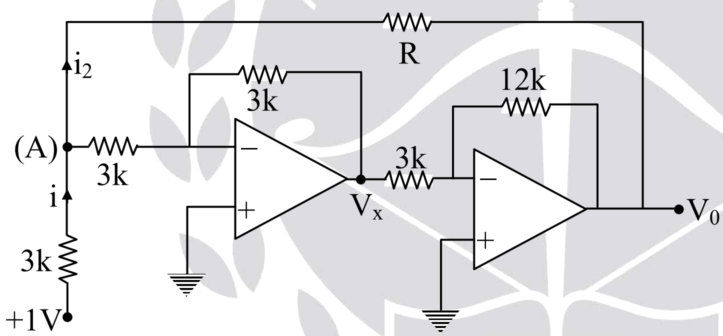
$$= \frac{g_{mn}}{g_{mp}}$$

31. In the circuit shown below, all OPAMPS are ideal. The current I = 0 A when the resistance R = ________ kΩ



31. Ans: 9

Sol:



At Node (A), KCL →

$i = i_1 + i_2 \Rightarrow \dfrac{1-V_A}{3k} = \dfrac{V_A - 0}{3k} + \dfrac{V_A - V_0}{R}$

Given i = 0

$\Rightarrow \dfrac{1-V_A}{3k} = 0 \;\Rightarrow V_A = 1 \rightarrow 0$

$\therefore \dfrac{1-0}{3k} + \dfrac{1-V_0}{R} = 0$

$\therefore 1 - V_0 = \dfrac{-R}{3k} \Rightarrow R = 3k(V_0 - 1)$

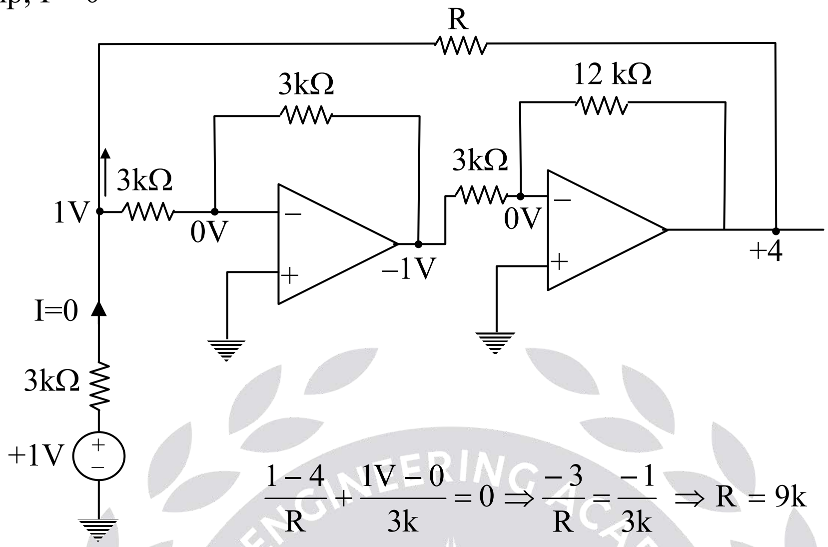
if we find V_0, we get the answer from Op-Amp (1), $V_x = \dfrac{-3k}{3k}(V_A) = -1V$

Also from op-Amp(2), $v_0 = \dfrac{-12k}{3k}(V_x) = -4(-1) = 4v$

$\therefore$ R = 3k (4–1) = 9kΩ

(OR)

Ideal op-amp; I = 0



$$\frac{1-4}{R}+\frac{1V-0}{3k}=0 \Rightarrow \frac{-3}{R}=\frac{-1}{3k} \Rightarrow R = 9k$$

End of Solution

32. The transfer function relating the input x(t) to the output y(t) of a system is given by G(s) = 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)

32. Ans: 0.466

Sol: $\frac{Y(s)}{X(s)}=\frac{1}{s+3}$

Convert into differential equation

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

$\frac{dy}{dt}+3y=x(t)$ $\qquad$ $\frac{dy}{dt}+3y=u(t)$

Apply Laplace Transform

$sY(s)-Y(0)+3Y(s)=X(s)$

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

$Y(s)(s+3)=\frac{3s+1}{s}=\frac{3\left(s+\frac{1}{3}\right)}{s}$

$Y(s)(s+3)=\frac{3\left(s+\frac{1}{3}\right)}{s(s+3)}=\frac{A}{s}+\frac{B}{s+3}$

$$A = \frac{3\times\frac{1}{3}}{3} = \frac{1}{3}$$

$$B = \frac{3\left(-3+\frac{1}{3}\right)}{3} = \frac{-1(-9+1)}{3} = \frac{-1(-8)}{3} = \frac{8}{3}$$

$$y(t) = \frac{1}{3} + \frac{8}{3}e^{-3t}$$

$$y(1) = \frac{1}{3} + \frac{8}{3}e^{-3} = 0.466$$

End of Solution

33. $X = X_1X_0$ 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) $X_1\overline{Y}_1 + X_0\overline{Y}_0\overline{Y}_1 + X_0\overline{Y}_0X_1$

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

(d) $X_1Y_1 + X_0\overline{Y}_0Y_1 + X_0\overline{Y}_0\overline{X}_1$

33. Ans: (b)

Sol: Method:-1

$X > Y$ if $X_1 > Y_1$ and $X_0 > Y_0$

i.e $X > Y$ if $X_1\overline{Y}_1 + (X_1 \odot Y_1)\ X_0\overline{Y}_0$

$$= X_1\overline{Y}_1 + \left[\overline{X}_1\overline{Y}_1 + X_1Y_1\right]X_0\overline{Y}_0 \qquad = X_1\overline{Y}_1 + X_1\overline{Y}_1X_0\overline{Y}_0 + X_1Y_1X_0\overline{Y}_0$$

$$= \overline{Y}_1\left[X_1 + \overline{X}_1X_0\overline{Y}_0\right] + X_1Y_1X_0\overline{Y}_0 \quad = \overline{Y}_1\left[X_1 + X_0\overline{Y}_0\right] + X_1Y_1X_0\overline{Y}_0$$

$$= X_1\overline{Y}_1 + \overline{Y}_1X_0\overline{Y}_0 + X_1Y_1X_1\overline{Y}_0 \qquad = X_1\overline{Y}_1 + \overline{Y}_1X_0\overline{Y}_0 + X_1X_0\overline{Y}_0$$

$$= X_1\overline{Y}_1 + X_0\overline{Y}_0\overline{Y}_1 + X_0\overline{Y}_0X_1$$

Method:-2

X_1 X_0 Y_1 Y_0	X > Y
0 1 0 0	1
1 0 0 0	1
1 0 0 1	1
1 1 0 0	1
1 1 0 1	1
1 1 1 0	1

$\Rightarrow$ X > Y expression is

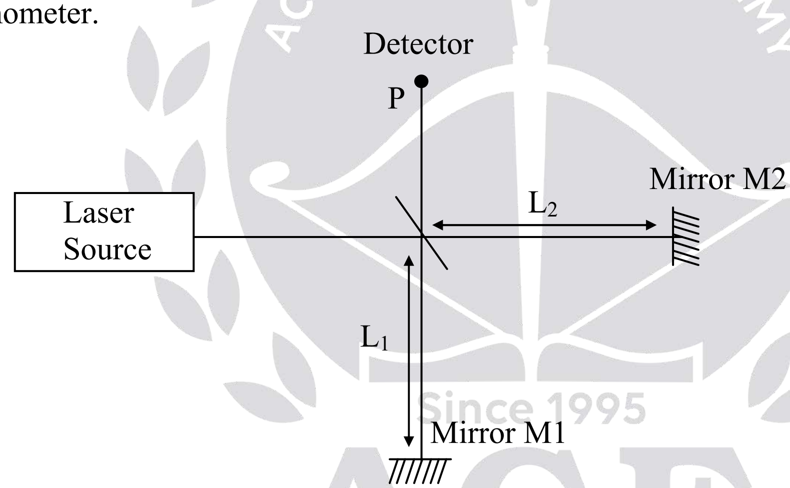
$S = \sum m(4, 8, 9, 12, 13, 14)$

X_1X_0 \ 1/0	00	01	11	10
00				
01	1			
11	1	1		1
10	1	1		

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

End of Solution

34. Consider a Michelson interferometer as shown in the figure below. When the wavelength of the laser light source is switched from 400 nanometer ti 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.



34. Ans: 1000

Sol: For bright spot OPD = $n\lambda_1$

$$2x = n\lambda_1$$

For dark spot $2x = (2m + 1)\dfrac{\lambda_2}{2}$

$n\lambda_1 = (2m + 1)\dfrac{\lambda_2}{2}$

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

$5n = (2m + 1)2$

$5n = 4m + 2$

For m = 2 conditions satisfied

$n = 2$

So, $2x = n\lambda$

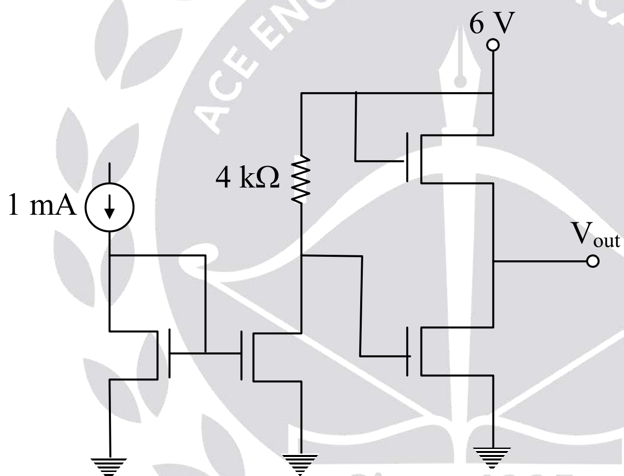
$2x = (2)(500nm)$

$2x = 1000nm$

Optical path difference = 2x = 1000 nm

End of Solution

35. 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.



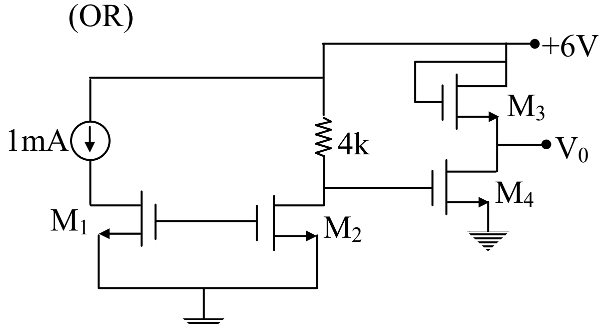
35. Ans: 4

Sol: $(6 - V_0 - V_{TH})^2 = (2 - V_{TH})^2$

$6 - V_0 - V_{TH} = 2 - V_{TH}$

$V_0 = 4V$

(OR)



M_1 and $M_2 \rightarrow$ are in current mirror, since identical M_1 and M_2 and current mirror

$\Rightarrow I_{4k} = 1mA$

$\therefore V_{G4} = 2V$ ($\because$ $6 = I_{4k}(4k) + V_{G4}$).

$\Rightarrow I_{D_3} = I_{D_4}$

$\therefore (6 - V_0 - V_{th})^2 = (2 - 0 - V_{th})^2$

$6 - V_0 = 2 \Rightarrow V_0 = 4V$.

End of Solution

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

(a) f (z) = x + i y

(b) $f(z) = x^2 - y^2 + i\,2xy$

(c) f(z) = constant

(d) $f(z) = x^2 + y^2$

36. Ans: (c)

Sol: Given f(z) = u (x,y) + i v(x,y) is analytic

And conjugate f*(z) = u(x,y) – i v(x,y) also analytic in entire complex plane.

f(z) is analytic $\Rightarrow$ C R equations holds

$$\frac{\partial x}{\partial x} = \frac{\partial v}{\partial y} \text{ ad } \frac{\partial y}{\partial y} = -\frac{\partial v}{\partial x}$$

f*(z) is analytic $\Rightarrow \frac{\partial x}{\partial x} = -\frac{\partial v}{\partial y}$ ad $\frac{\partial y}{\partial y} = -\frac{\partial v}{2x}$

hence $\Rightarrow \frac{\partial v}{\partial y} = -\frac{\partial v}{\partial y}$ and $\frac{\partial v}{\partial x} = -\frac{\partial v}{\partial x}$

clearly $\frac{\partial v}{\partial y} = 0$ and $\frac{\partial v}{\partial x} = 0$

$\therefore$ v = constant

$\Rightarrow$ u = constant

$\therefore$ f(z) = u + i v = constant

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37. 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) $\begin{bmatrix} 50 \\ -35 \end{bmatrix}$

37. Ans: (d)

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

$\dot{x} = AX + K$

Where $A = \begin{bmatrix} 1 & 2 \\ -3 & -4 \end{bmatrix}$

$K = \begin{bmatrix} 20 \\ 10 \end{bmatrix}$

$\dot{x}(t) = Ax(t) + K$

$sX(s) - X(0) = AX(s) + \dfrac{K}{s}$

$(sI - A)\, X(s) = X(0) + \dfrac{K}{s}$

$X(s) = (sI - A)^{-1}\, X(0) + (sI - A)^{-1} \dfrac{K}{s}$

$x(t) = L^{-1}(sI - A)^{-1} x(0) + L^{-1}(sI - A)^{-1} \dfrac{K}{s}$

$x(\infty) = \underset{s\to 0}{Lt}\, sX(s) = \underset{s\to 0}{Lt}\, s\left[(sI - A)^{-1} x(0) + (sI - A)^{-1} \dfrac{K}{s}\right]$

$= (sI - A)^{-1} x(0) + \underset{s\to 0}{Lt}(sI - A)^{-1} \dfrac{K}{s}$

$= 0 + \underset{s\to 0}{Lt}(sI - A)^{-1} K$

$$(sI - A)^{-1} = \left[s\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} - \begin{bmatrix} 1 & 2 \\ -3 & -4 \end{bmatrix} \right]^{-1}$$

$$= \begin{bmatrix} s-1 & -2 \\ 3 & s+4 \end{bmatrix}^{-1}$$

$$= \begin{bmatrix} s-1 & -2 \\ 3 & s+4 \end{bmatrix}^{-1}$$

$$= \frac{1}{(s+4)(s-1)+6}\begin{bmatrix} s-4 & 2 \\ -3 & s-1 \end{bmatrix}$$

$$x(\infty) = \underset{s\to 0}{\mathrm{Lt}}\, s \frac{\begin{bmatrix} s-4 & 2 \\ -3 & s-1 \end{bmatrix}}{(s+4)(s-1)+6} \frac{\begin{bmatrix} 20 \\ 10 \end{bmatrix}}{s}$$

$$= \frac{\begin{bmatrix} 4 & 2 \\ -3 & -1 \end{bmatrix}\begin{bmatrix} 20 \\ 10 \end{bmatrix}}{-4+6}$$

$$= \frac{\begin{bmatrix} 80+20 \\ -60-10 \end{bmatrix}}{2}$$

$$x(\infty) = \frac{\begin{bmatrix} 100 \\ -70 \end{bmatrix}}{2} = \begin{bmatrix} 50 \\ -35 \end{bmatrix}$$

End of Solution

38. 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 $Y(\omega)$ respectively and $|X(0)|^2 = 4$, the value of $|Y(0)|^2$ is _______.

38. Ans: 9

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

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

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

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

$$Y(\omega) = X(\omega).H(\omega)$$

$$|Y(\omega)|^2 = |X(\omega)|^2\ .|H(\omega)|$$

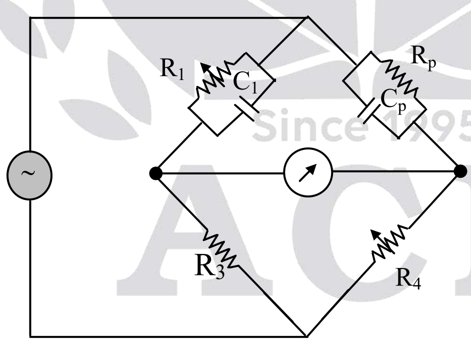
$$\therefore |Y(0)|^2 = |X(0)|^2\ .|H(0)|^2 = 4\frac{9}{4} = 9$$

$$H(0) = 1 + \frac{1}{2} = \frac{3}{2}$$

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

End of Solution

39. The parallel resistance-capacitance bridge shown below has a standard capacitance value of $C_1 = 0.1\ \mu F$ and a resistance value of $R_3 = 10\ k\Omega$. The bridge is balanced at a supply frequency of 100 Hz for $R_1 = 375\ k\Omega$, $R_3 = 10\ k\Omega$ and $R_4 = 14.7\ k\Omega$. The value of the dissipation factor $D = 1/(\omega R_p C_p)$ of the parallel combination of C_p and R_p is ________ . (Answer should be rounded off to THREE decimal places)



39. Ans: 0.042

Sol: $z_1 z_2 = z_2 z_3$

$$\left(R_1 // \frac{1}{j\omega C_1}\right)(R_4) = \left(R_2 // \frac{1}{j\omega C_2}\right)(R_3)$$

$$\left(\frac{R_1}{1 + j\omega C_1 R_1}\right)(R_4) = \left(\frac{R_2}{1 + j\omega C_2 R_2}\right)(R_3)$$

$$\frac{R_1R_4}{1+j\omega C_1R_1} = \frac{R_2R_3}{1+j\omega C_2R_2}$$

$$R_1R_4 + j\omega R_1R_4R_2C_2 = R_2R_3 + j\omega R_1R_2R_3C_1$$

$$R_1R_4 = R_2R_3$$

$$R_2 = \frac{R_1R_4}{R_3} = \frac{375k \times 14.7k}{10k} = 551.25k\Omega$$

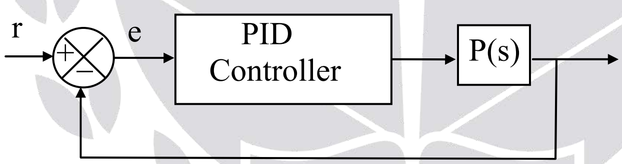
$$R_1R_4R_2C_2 = R_1R_2R_3C_1$$

$$C_2 = \frac{R_1R_2R_3C_1}{R_1R_4R_2} = \frac{R_3C_1}{R_4} = \frac{0.1\mu F \times 10k}{14.7k} = 0.068\mu F$$

$$D = \frac{1}{2\pi \times 100 \times 551.25k \times 0.068\mu F} = 0.04248$$

End of Solution

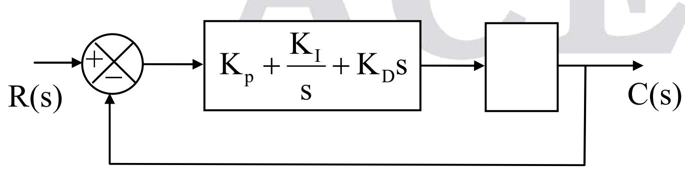
40. In the control system shown in the figure below, a reference signal $r(t) = t^2$ is applied at time $t = 0$. The control system employs a PID controller $C(s) = K_p + K_I/s + K_Ds$ and the plant has a transfer function $P(s) = 3/s$. If $K_p = 10$, $K_I = 1$ and $K_D = 2$, the steady state value of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



(a) 0 (b) 2/3 (c) 1 (d) ∞

40. Ans: (b)

Sol:



$$G(s) = \left(10 + \frac{1}{s} + 2s\right)\left(\frac{3}{s}\right)$$

$$G(s) = \frac{3(2s^2 + 10s + 1)}{s^2}$$

$$r(t) = t^2$$

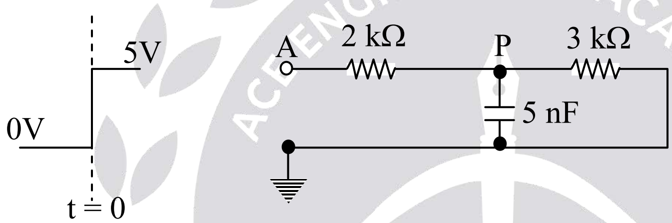
Steady state error $e_{ss}(t^2) = \left(\dfrac{2}{K_a}\right)$

$$K_a = \underset{s\to 0}{\text{Lt}}\, s^2G(s) = \underset{s\to 0}{\text{Lt}}\, s^2\left[\frac{3(2s^2+10s+1)}{s^2}\right] = 3$$

$$e_{ss} = \frac{2}{K_a} = \frac{2}{3}$$

End of Solution

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 $t = 6\ \mu s$ is _______ V. (Answer should be rounded off to two decimal places)



41. Ans: 1.896

Sol: $V(t) = V(\infty) + [V(0) - V(\infty)]e^{-t/\tau}$

$V(0) = 0V$

$$V(\infty) = 5\left[\frac{3k}{5k}\right] = 3V$$

$\tau = R_{eq}.C$

$$R_{eq} = 2k \,//\, 3k = \frac{6}{5}k$$

$$T = \frac{6}{5}k \times 5nF = 6\mu\,sec$$

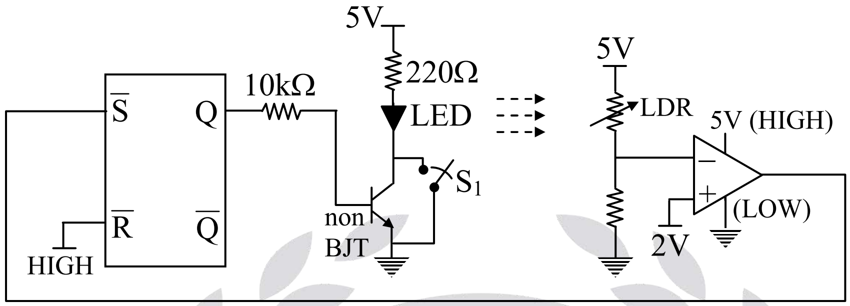
$V(t) = 3[1 - e^{-t/6\mu}]$

$V(t = 6\mu)$

$V(t) = 3[1 - e^{-1}] = 3[1 - 0.367] = 1.896\text{Volts}$

End of Solution

42. 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 = 0s, 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 remains OFF after S_1 is opened

42. Ans: (a)

Sol: Step (i):

At t = 0 sec ⇒ switch S_1 is closed

⇒ LED is ON ⇒ LDR resistance becomes 500Ω

⇒ $V_{1k\Omega} = 2V \Rightarrow \overline{S} = 0$ and $\overline{R} = 1$

i.e S = 1 and R = 0 ⇒ Q = 1

⇒ As Q = 1 ⇒ BJT is ON

Step (ii):

At t = 1msec ⇒ Switch S_1 is open, but BJT is still ON as Q =1

Thus LED is permanently ON once the switch is closed.

End of Solution

43. The frequency response of a digital filter H(ω) has the following characteristics

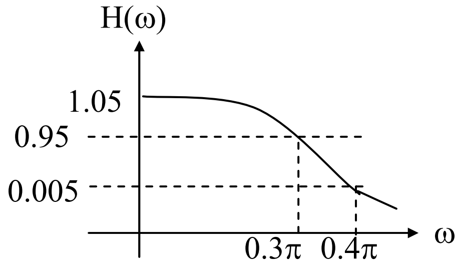
Passband: $0.95 \le |H(\omega)| \le 1.05$ for $0 \le \omega \le 0.3\pi$ and

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.

43. Ans: 8

Sol:



$$\therefore \Omega = \frac{\omega}{f_s}$$

$$\Rightarrow f_s = \frac{\omega}{\Omega} = \frac{1.2k(2\pi)}{0.3\pi} = \frac{2.4}{0.3} = 8\text{kHz}$$

End of Solution

44. 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

44. Ans: (a)

Sol: $P_{inc} = 100$ W

Light intensity $I = \frac{P_{inc}}{4\pi r^2} = \frac{100}{4\pi \times 1^2} = 7.96 \text{ W/m}^2$

Detector diameter = d = 2 cm = 0.02 m, r = d/2 = 0.01 m

Power incident on photo detector = $7.96 \text{ W/m}^2 \times \pi \times 0.01^2 \text{ m}^2 = 25\times0.01^2$ W

Photo current generated in detector = I = RP = $0.4\text{A/W} \times 25 \times 0.01^2$ W = 1 mA

End of Solution

45. 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.

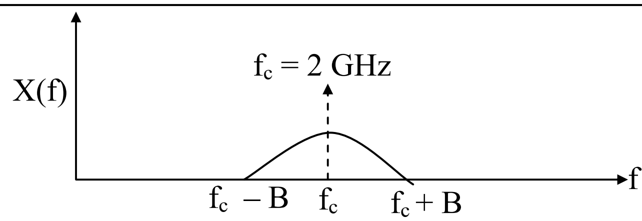


Figure (a)

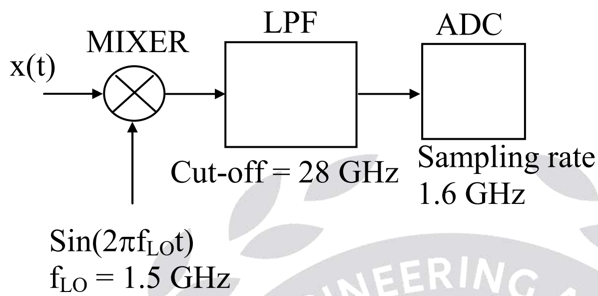
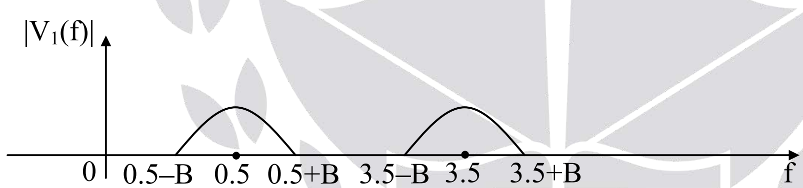


Figure (b)

45. Ans: 300

Sol: $V_1(t) = x(t)\sin(2\pi f_0 t)$

$$V_1(f) = \frac{1}{2j}\left[X(f - f_0) - X(f + f_0)\right]$$



$V_1(f)$ passed through LPF with cut-off frequency 2.8GHz

Sampled at 1.6 GHz $f_s \geq 2f_m$

$1.6 \geq 2[0.5 + B]$

$1.6 \geq 1 + 2B$

$2B \leq 0.6$

$B \leq 0.3\,\text{GHz}$

$B \leq 300\,\text{MHz}$

46. 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(ωt) where ω = 5 rad/s, the steady-state amplitude of the output y(t) is

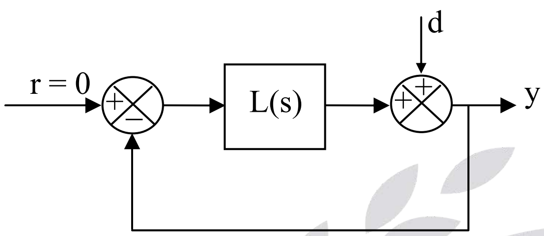


Figure (a)

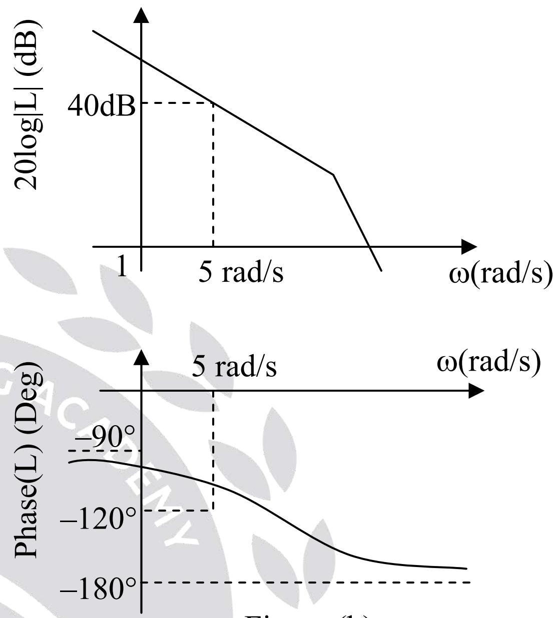


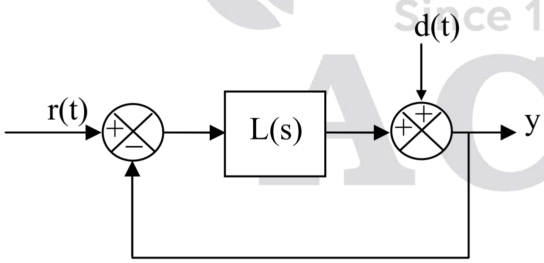
Figure (b)

(a) 1.00×10^{-3} (b) 2.50×10^{-3}

(c) 5.00×10^{-3} (d) 10.00×10^{-3}

46. Ans: (a)

Sol:



$$y = \frac{rL + d}{1 + L}$$

$$\frac{y}{d} = \frac{1}{1+L}$$

$$\Rightarrow y = \frac{d}{1+L} = \frac{0.1}{1+100} \approx 0.1 \times 10^{-2} = 10^{-3}$$

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

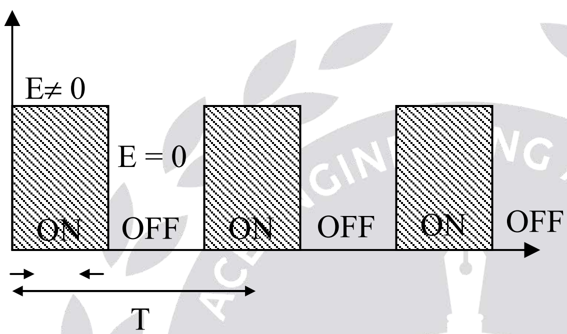
(a) 1 (b) 10

(c) 100 (d) 1000

47. Ans: (d)

Sol: $P_{width} = 1\text{nanosec}$

Pulsed laser $f = 1\text{kHz} \rightarrow T = \frac{1}{f} = 1\text{m sec}$



T = Time period

Energy of laser pulse width $= \frac{E}{T}$

$$P_{peak} = \frac{E}{\Delta t} = P_{single\ pulse}$$

E will be same for both cases

$P_{avg} \times T = E$

$P_{peak} \times \Delta t = E$

By equating E

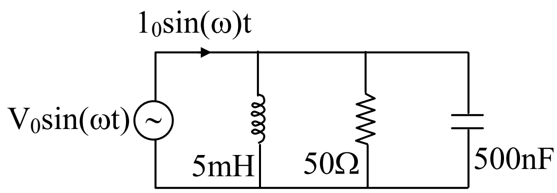
$P_{avg} \times T = P_{peak} \times \Delta t$

$$\frac{P_{avg} \times T}{\Delta t} = P_{Peak}$$

$$\frac{1\text{mW} \times 1\text{m sec}}{1\text{n sec}} = \frac{10^{-3} \times 10^{-3}}{10^{-9}}$$

$$= 1000\text{W}$$

48. In the circuit shown below, the angular frequency ω at which the current is in phase with the voltage is ________ rad/s.



48. Ans: 20

Sol: At resonance

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{5\times10^{-3}\times500\times10^{-9}}} = \frac{1}{\sqrt{25\times10^{-10}}} = \frac{1}{5\times10^{-5}} = \frac{10^5}{5} = 20000\text{rad/sec} = 20\text{krad/sec}$$

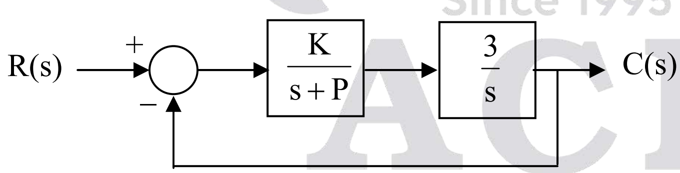
End of Solution

49. In a control system with unity gain feedback, the plant has the transfer function p(s) = 3/x. Assuming that a controller of the form C(s) = K.(s+p) is used , where k is a positive constant, the value of p for which the root-locus of the closed-oop 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

49. Ans: (c)

Sol:



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

$$s = 3 + j3\sqrt{3}$$

At this point angle condition to be satisfied

$$\phi = \angle G(-3 + j3\sqrt{3}) = \frac{\angle(3k)}{\angle -3 + j3\sqrt{3}\ \ \angle -3 + j3\sqrt{3} + P}$$

$$= \frac{\angle 0^0}{(\pi - \tan^{-1}(\sqrt{3}))\left(\tan^{-1}\left(\frac{3\sqrt{3}}{P-3}\right)\right)}$$

$$-\left(120^0 + \tan^{-1}\left(\frac{3\sqrt{3}}{P-3}\right)\right) = -180^0$$

$$\tan^{-1}\left(\frac{3\sqrt{3}}{P-3}\right) = 60^0$$

$$\frac{3\sqrt{3}}{P-3} = \sqrt{3}$$

$$P - 3 = 3$$

$$\therefore P = 6$$

End of Solution

50. The function p(x) is given by $p(x) = A/x^{\mu}$ 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) $1/(\mu-1)$ (d) $1/(\mu+1)$

50. Ans: (a)

Sol: Given $P(x) = \frac{A}{x^u}$ $1 \le x < \infty$

For a valid probability density function

$$\int_1^{\infty} P(x)dx = 1$$

$$\Rightarrow \int_1^{\infty} \frac{A}{x^u} dx = 1 \Rightarrow A - \left.\frac{x^{-u+1}}{-u+1}\right|_1^{\infty} = 1$$

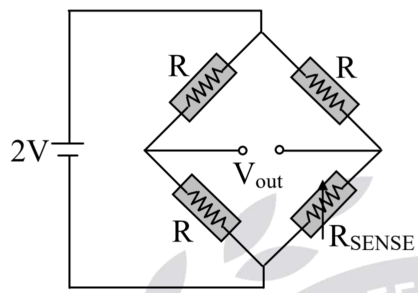
$$\frac{A}{1-u}[0-1] = 1$$

$$\Rightarrow \frac{A}{u-1} = 1$$

$$\therefore A = u - 1$$

End of Solution

51. 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

51. Ans: (d)

Sol: $V_{Bri} = \frac{V_s}{4}\frac{\Delta R}{R}$

$V_{Bri} = \frac{V_s}{4} G_f \times \text{strain}$

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

Strain = $1 \times 10^{-3} = 1000\mu$

End of Solution

52. 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 resistance of a device by measuring a full-range voltage of 2V 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 12kΩ and a maximum power rating of 100μW is to be measure safely with this meter, the choice for range-setting on the meter for best resolution in measurement, in kΩ, is

(a) 2 (b) 20

(c) 200 (d) 2000

52. Ans: (c)

Sol: Full range voltage : 2 volts

Maximum full scale current rating in individual range are:

200Ω range $\Rightarrow \dfrac{2}{200} = 10\text{mA}$

2 kΩ range $\Rightarrow \dfrac{2}{200} = 1\text{mA}$

20 kΩ range $\Rightarrow$ 0.1 mA = 100 nA

200 kΩ range $\Rightarrow$ 0.01 mA = 10 nA

2000 kΩ range $\Rightarrow$ 1 nA

Specifications of given device : 100μW , 8 kΩ – 12 kΩ

Current rating corresponding to 8 kΩ

$$\Rightarrow I_1 = \sqrt{\frac{100\times10^{-6}}{8\times10^{3}}}$$

$$= \sqrt{12.5\times10^{-9}} = \sqrt{1.25\times10^{-8}}$$

$$I_1 = 0.118 \text{ mA}$$

Current rating corresponding to 12 kΩ

$$\Rightarrow I_2 = \sqrt{\frac{100\times10^{-6}}{12\times10^{3}}}$$

$$= \sqrt{8.33\times10^{-9}} = \sqrt{0.833\times10^{-8}}$$

$$= 0.0912 \text{ mA}$$

If 20kΩ range selected then maximum current flow would be 0.1mA and it is more than current rating of device (0.0912 mA) if resistance of device is 12 kΩ. Hence device would be damaged.

The next best range for measurement is 200kΩ where maximum current rating of range is 0.01 mA which is less than current rating of device and it is safe. The best resolution is possible for lower safe range for given specifications.

End of Solution

53. A discrete-time signal $x(n) = e^{j\left(\frac{5\pi}{3}\right)n} + e^{j\left(\frac{\pi}{4}\right)n}$ 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

53. Ans: 6

Sol: $x(n) = e^{j\left(\frac{5\pi}{3}\right)n} + e^{j\left(\frac{\pi}{4}\right)n}$

$$x_d(n) = x(4n) = e^{j\left(\frac{20\pi}{3}\right)n} + e^{j\pi n}$$

$$\omega_0 = GCD\left(\frac{20\pi}{3}, \pi\right) = GCD\left(\frac{20\pi}{3}, \frac{3\pi}{3}\right)$$

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

Fundamental period = $N = \dfrac{2\pi}{\frac{\pi}{3}} = 6$

End of Solution

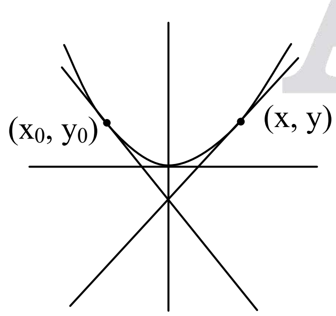
54. The curve $y = f(x)$ is such that the tangent to the curve at every point (x, y) has a Y-axis intercept c, given by $c = -y$. then, $f(x)$ is proportional to

(a) x^{-1} (b) x^2

(c) x^3 (d) x^4

54. Ans: (b)

Sol: For the curve $y = x^2$, every point (x, y) on the curve, if we draw the tangent at (x, y) the tangent intersects y-axis with negative intercept.



(OR)

From the option (b) if we take the curve $y = x^2$. Let (x_0, y_0) is a point on the curve. Then tangent at (x_0, y_0) is $y - y_0 = m(x - x_0)$

$\Rightarrow y - y_0 = 2x_0(x - x_0)$ $\qquad \frac{d}{dx}(x^2) = 2x$

$\Rightarrow y - y_0 = 2x_0(0 - x_0)$ $\qquad$ (Since it has y intercept only)

$\Rightarrow y = y_0 - 2x_0^2$

$\Rightarrow y = y_0 - 2y_0 \quad (\because y_0 = x_0^2)$

$\Rightarrow y = -y_0$

End of Solution

55. In a control system with unity gain feedback, the transfer function of the loop-gain function is $L(s) = 9e^{-0.1s}/s$. The phase margin of the loop-gain function L(S) is ________ degree.

55. Ans: 38.43

Sol: $L(s) = \frac{9e^{-0.1s}}{s}$

$s = j\omega$

$L(j\omega) = \frac{9e^{-j0.1\omega}}{j\omega}$

$M = \frac{9}{\omega}$

$\phi = -0.1\omega \times \frac{180^0}{\pi} - 90^0$

$\omega_{gc} \quad M = 1$

$\frac{9}{\omega_{gc}} = 1$

$\omega_{gc} = 9 \text{rad/sec}$

$\phi_{sys}(\omega_{gc}) = -0.1\omega \times 9 \times \frac{180^0}{\pi} - 90^0 = -141.5^0$

Phase margin $\Rightarrow$ $PM = 180^0 + \phi_{sys}(\omega_{gc}) = 38.43^0$

End of Solution

ESE / GATE / PSUs - 2020 ADMISSIONS OPEN

CENTER	COURSE	BATCH TYPE	DATE
HYDERABAD - DSNR	GATE + PSUS – 2020	Regular Batches	26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - DSNR	ESE + GATE + PSUs - 2020	Regular Batches	21st March, 26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - DSNR	GATE + PSUs - 2020	Short Term Batches	29th April, 6th, 11th, 18th May 26th May, 2nd June, 2019
HYDERABAD - DSNR	GATE + PSUs - 2020	Morning/Evening Batch	24th February 2019
HYDERABAD - DSNR	ESE – 2019 STAGE-II (MAINS)	Regular Batch	17th Feb 2019
HYDERABAD - Abids	GATE + PSUS – 2020	Regular Batches	26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - Abids	GATE + PSUs - 2020	Short Term Batches	29th April, 6th, 11th, 18th May 26th May, 2nd June, 2019
HYDERABAD - Abids	ESE + GATE + PSUs - 2020	Morning Batch	24th February 2019
HYDERABAD - Abids	ESE – 2019 STAGE-II (MAINS)	Regular Batch	17th Feb 2019
HYDERABAD - Abids	GATE + PSUs - 2020	Weekend Batch	24th February 2019
HYDERABAD - Abids	ESE+GATE + PSUs - 2020	Spark Batches	11th May, 09th June 2019
HYDERABAD - Kukatpally	GATE + PSUs - 2020	Morning/Evening Batch	24th February 2019
HYDERABAD - Kukatpally	GATE + PSUS – 2020	Regular Batches	17th May, 1st, 16th June, 1st July 2019
HYDERABAD - Kukatpally	GATE + PSUs - 2020	Short Term Batches	29th April, 6th, 11th, 18th May 26th May, 2nd June, 2019
HYDERABAD - Kothapet	ESE + GATE + PSUS – 2020	Regular Batches	21st March, 26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - Kothapet	ESE+GATE + PSUs - 2020	Spark Batches	11th May, 09th June 2019
DELHI	ESE+GATE+PSUs - 2020	Weekend Batches	9th Mar 2019
DELHI	ESE+GATE+PSUs - 2020	Regular Evening Batch	18th Feb 2019
DELHI	ESE+GATE+PSUs - 2020	Regular Day Batch	11th May 2019
DELHI	ESE+GATE+PSUs - 2020	Spark Batch	11th May 2019
DELHI	GATE+PSUs - 2020	Short Term Batches	11th, 23rd May 2019
BHOPAL	ESE+GATE+PSUs - 2020	Regular Day Batch	01st Week of June 2019
BHUBANESWAR	GATE+PSUs - 2020	Weekend Batch	16th Feb 2019
BHUBANESWAR	GATE+PSUs - 2020	Regular Batch	02nd Week of May 2019
CHENNAI	GATE+PSUs - 2020 & 21	Weekend Batch	16th Feb 2019
CHENNAI	GATE+PSUs - 2020	Regular Batch	02nd Week of May 2019
BANGALORE	GATE+PSUs - 2020 & 21	Weekend Batch	23rd Feb 2019
BANGALORE	GATE+PSUs - 2020	Regular Batch	17th June 2019