



GATE 2023

**INSTRUMENTATION
ENGINEERING**

**Memory based
Questions
& Solutions**



Corporate Office: 44-A/1, Kalu Sarai, New Delhi-110016
MADE EASY Centres : Delhi , Hyderabad , Jaipur, Bhopal,
Lucknow, Bhubaneswar, Pune, Kolkata



9021300500



www.madeeasy.in

**Exam held
on 11th Feb, 2023
Forenoon
Session**

SECTION - A

GENERAL APTITUDE

Q.1 How many 5-digit number can be formed by using 3, 4, 5 and 6 if exactly One digit appearing twice.

Ans. (240)

We have 5 digits out of which 2 are identical.

$$\text{Number of ways} = \frac{5!}{2!} = \frac{120}{2} = 60$$

Out of four digit exactly one digit appearing twice.

$$\text{Number of ways} = {}^4C_1 = 4$$

$$\text{Total 5-digit number} = 4 \times 60 = 240$$

End of Solution

Q.2 Disagree : Protest :: Agree : _____

(a) Refuse

(b) Recommend

(c) Refute

(d) Pretext

Ans. (b)

End of Solution

Q.3 The village was nested in a green spot ____ the ocean and the field

(a) in

(b) at

(c) through

(d) between

Ans. (d)

End of Solution

Q.4 Residency is a famous housing complex with many well-established individuals among its residents. A recent survey conducted among the residents of the complex revealed that all of those residents who are well established in their respective fields happen to the academicians. The survey also revealed that most of these academicians are authors of some best-selling books. Based only on the information provided above, which one of the following statements can be logically inferred with certainty?

(a) Some authors of best-selling books are residents of the complex who are well-established in their fields

(b) All academicians residing in the complex are well establishing in their fields.

(c) Some residents of the complex who are well established in their fields are also authors of some best-selling books.

(d) Some academicians residing in the complex are well established in their fields.

Ans. (d)

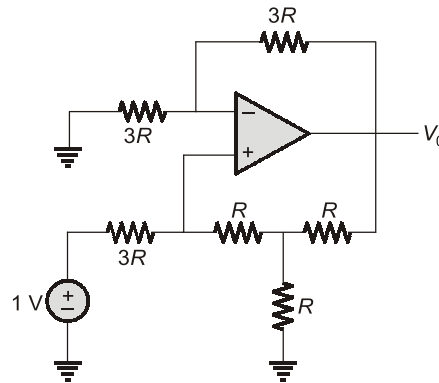
End of Solution



SECTION - B

TECHNICAL

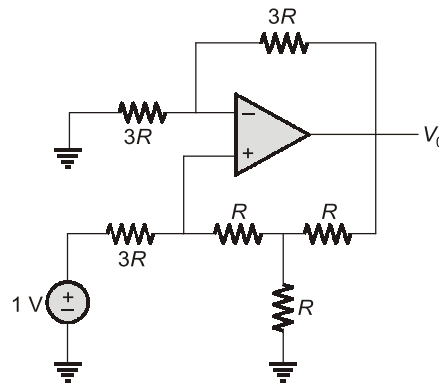
Q.5 For Ideal op-amp shown below:



The value of V_0 is _____ V.

Ans. (2)

Assuming op-amp is not saturated.



$$\frac{V_A - 1}{4R} + \frac{V_A}{R} + \frac{V_A - V_0}{R} = 0$$

$$\frac{V_A - 1}{4} + V_A + V_A - V_0 = 0$$

$$9V_A - 1 - 4V_0 = 0$$

$$V_A = \frac{1}{9} + \frac{4}{9}V_0$$

∴ Current flowing through $3R \Omega$.

$$i = \frac{1 - V_A}{4R} = \frac{1}{4R} \left[1 - \left(\frac{1}{9} + \frac{4V_0}{9} \right) \right]$$

∴ Voltage at non-inverting terminal

$$V_+ = 1 - \frac{1}{4R} \times 3R \left[1 - \left(\frac{1}{9} + \frac{4V_o}{9} \right) \right]$$

$$V_+ = 1 - \frac{3}{4} \left[\frac{8}{9} - \frac{4V_o}{9} \right]$$

$$V_+ = 1 - \frac{2}{3} + \frac{V_o}{3}$$

$$V_+ = \frac{1}{3} + \frac{V_o}{3}$$

Using virtual short concept

$$V_+ = V_- = \frac{1}{3} + \frac{V_o}{3}$$

Applying KCL at inverting node

$$\frac{0 - V_-}{3R} = \frac{V_- - V_o}{3R}$$

$$-V_- = V_- - V_o$$

$$V_o = 2V_-$$

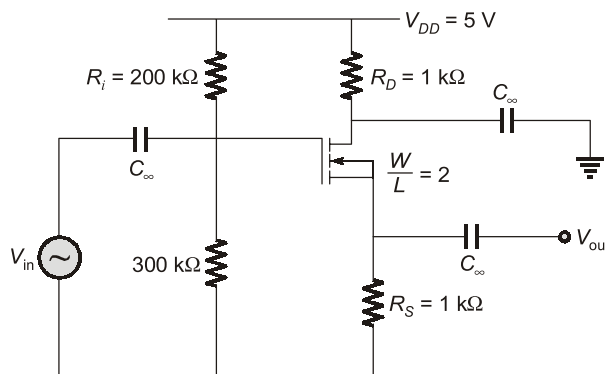
$$V_o = 2 \left[\frac{1}{3} + \frac{V_o}{3} \right]$$

$$3V_o = 2 + 2V_o$$

$$V_o = 2 \text{ Volt}$$

End of Solution

- Q.6** Figure below shows a feedback amplifier constructed using an nMOS transistor. Assume that $\mu_n C_{ox} = 1 \text{ mA/V}^2$, threshold voltage $V_T = 1 \text{ V}$ and $W/L = 2$. The bias voltage at the drain terminal is 4 V. The capacitor C_∞ offer zero impedance once at signal frequency. The ratio V_{out}/V_{in} is _____.





NST-2 NATIONAL SCHOLARSHIP TEST 2024

For **ESE, GATE & PSUs 2024**
Offline & Online Long-Term Courses

Register at : www.madeeasy.in

Last Date to Register (Online) : **21st Feb, 2023**

Test Date (Online) : **27th Feb, 2023**

Time Duration 45 Minutes	Total Questions 50 Questions	Total Marks 100 Marks	Negative Marking 0.66 Marks	Streams CE, ME, EE, EC, CS, CH
-----------------------------	---------------------------------	--------------------------	--------------------------------	-----------------------------------


9021300500


nst@madeeasy.in


nst.madeeasy.in

Scan to
Register 

Scholarship applicable on batches commencing between
1st March, 2023 to 31st May, 2023

Delhi Centre : 44 - A/1, Kalu Sarai, Near Hauz Khas Metro Station, New Delhi - 110016 | **Ph** : 9021300500

MADE EASY Centres : Delhi | Hyderabad | Jaipur | Bhopal | Lucknow | Bhubaneswar | Pune | Kolkata | www.madeeasy.in

Ans. (0.66)

Given : $V_D = 4 \text{ V}, \frac{W}{L} = 2, V_T = 1 \text{ V}$

$$\mu_n C_{ox} = 1 \text{ mA/V}^2$$

Given amplifier is common drain amplifier.

Now, $g_m = \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_T)$

$$V_{GS} = V_G - V_S$$

$$V_{GS} = \frac{5 \times 300}{500} - I_D R_S$$

$$V_{GS} = 3 - I_D R_S$$

Also, $I_D = \frac{5 - V_D}{R_D} = \frac{5 - 4}{1} = 1 \text{ mA}$

$\therefore V_{GS} = 3 - 1$

$$V_{GS} = 2 \text{ Volt}$$

Hence, $g_m = 1 \times 10^{-3} \times 2[2 - 1]$

$$g_m = 2 \text{ mA/V}$$

\therefore For common drain amplifier,

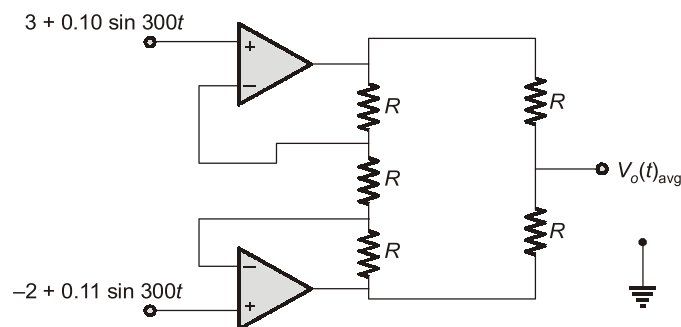
$$\frac{V_{out}}{V_{in}} = \frac{g_m R_S}{1 + g_m R_S} \quad (\text{Taking } r_{ds} = \infty)$$

$$= \frac{2 \times 1}{1 + 2 \times 1}$$

$$\frac{V_{out}}{V_{in}} = \frac{2}{3} \text{ V/V}$$

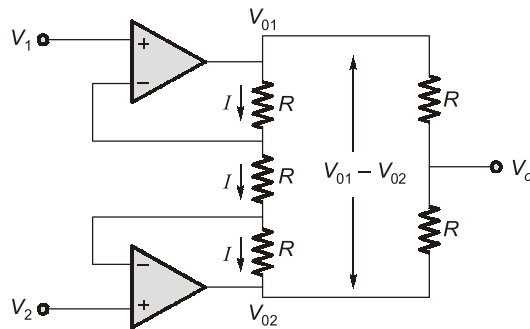
End of Solution

Q.7 For the circuit shown below :



The value of $V_o(t)_{avg} =$

Ans. (7.5)



$$V_1 = 3 + 0.1 \sin 100t$$

$$V_2 = -2 + 0.11 \sin 100t$$

$$I = \frac{V_1 - V_2}{R} = \frac{5 - 0.01 \sin 100t}{R}$$

$$V_{01} - V_{02} = I \times R + I \times R + I \times R = 3IR$$

$$\Rightarrow V_{01} - V_{02} = 15 - 0.03 \sin 100t$$

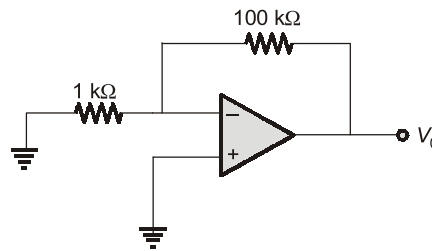
$$V_0 = \frac{(V_{01} - V_{02}) \times R}{R + R}, \text{ by using voltage divider rule}$$

$$V_0 = \frac{V_{01} - V_{02}}{2} = 7.5 - 0.015 \sin 100t$$

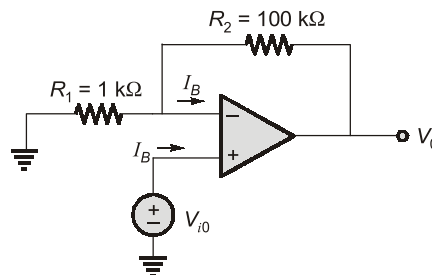
Hence, Average $V_0 = 7.5 \text{ V}$

End of Solution

Q.8 The opamp in the circuit shown is ideal, except that it has an input current of 1 nA and an input offset voltage of 10 μV . The resulting worst - case output voltage will be \pm _____ μV .



Ans. (1110)



KCL at inverting terminal:

$$\frac{0 - V_{i0}}{R_1} + \frac{V_0 - V_{i0}}{R_2} = I_B$$

$$\frac{V_0}{R_2} = I_B + \left(\frac{1}{R_1} + \frac{1}{R_2} \right) V_{i0}$$

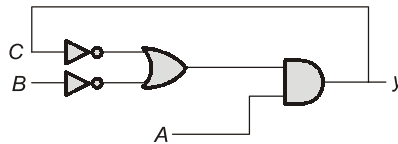
$$V_0 = I_B R_2 + \left(1 + \frac{R_2}{R_1} \right) V_{i0}$$

$$V_0 = 10^{-9} \times 100 \times 10^3 + \left(1 + \frac{100}{1} \right) \times 10 \times 10^{-6}$$

$$V_0 = 1110 \mu\text{V}$$

End of Solution

- Q.9** Given $A = B = 1$, initially $C = 1$, when circuit is turned on. If delays of AND, OR, NOT gates are 10 ns, 10 ns, 5 ns respectively then frequency of steady state oscillations of output y is _____ MHz.

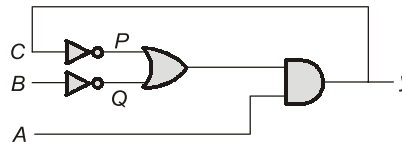


Ans. (20)

Given

$$A = B = 1$$

$$C = 1 \text{ (Initially)}$$



From circuit

$$P = \bar{C} = \bar{y}$$

$$Q = \bar{B}$$

Next state of the output

$$y^+ = A \cdot (\bar{B} + \bar{C})$$

$A = 1$ and $B = 1$

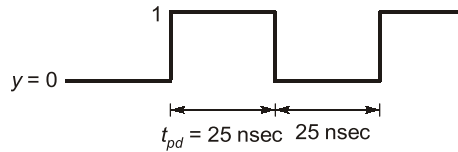
$$y^+ = 1 \cdot (0 + \bar{C}) = 0 + \bar{y} = \bar{y}$$

$$y^+ = \bar{y}$$

Overall propagation delay of circuit,

$$t_{pd} = 5 + 10 + 10 = 25 \text{ nsec}$$

So, after every 25 nsec the output will toggle.



Frequency of steady state oscillations,

$$f = \frac{1}{50 \times 10^{-9}} = 20 \times 10^6 \text{ Hz}$$

$$f = 20 \text{ MHz}$$

End of Solution

Q.10 Simplify $F(w, x, y, z) = \Sigma m(4, 5, 10, 11, 12, 13, 14, 15)$

- (a) $x\bar{y} + wy$ (b) $wx + \bar{w}x\bar{y} + w\bar{x}y$
 (c) $wx + wy + \bar{x}y$ (d) $\bar{x}y + \bar{w}y$

Ans. (a)

Given: $F(w, x, y, z) = \Sigma m(4, 5, 10, 11, 12, 13, 14, 15)$

K-Map:

$wx \backslash yz$	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{w}\bar{x}$				
$\bar{w}x$	1	1		
wx	1	1	1	1
$w\bar{x}$			1	1

$$F(w, x, y, z) = x\bar{y} + wy$$

End of Solution

Q.11 Match the following **List-1** to **List-2**.

- (1) $x \oplus x$ (P) 1
 (2) $x \oplus \bar{x}$ (Q) 0
 (3) $x \oplus 0$ (R) \bar{x}
 (4) $x \oplus 1$ (S) x



Announcing

FOUNDATION COURSES for **ESE 2024 • GATE 2024**

The Foundation Batches are taught comprehensively which cover the requirements of all technical-syllabus based examinations.

- ✓ Classes by experienced & renowned faculties.
- ✓ Exam oriented learning ecosystem.
- ✓ Systematic subject sequence & timely completion of syllabus.
- ✓ Result oriented teaching with comprehensive coverage.
- ✓ Comprehensive & updated study material.
- ✓ Concept of problems solving through workbooks.
- ✓ Regular performance assessment through class tests.
- ✓ Similar teaching pedagogy in online and offline classes.

OFFLINE BATCHES AT DELHI

Commencing from

- **14th Mar, 2023 • 11th April, 2023**
- **4th May, 2023 • 25th May, 2023**

LIVE-ONLINE BATCHES

Commencing from

- **15th Feb, 2023 • 14th Mar, 2023**
- **15th Apr, 2023 • 15th May, 2023**

Admissions open

Delhi Centre : 44 - A/1, Kalu Sarai, Near Hauz Khas Metro Station, New Delhi - 110016 | **Ph :** 9021300500

MADE EASY Centres : Delhi | Hyderabad | Jaipur | Bhopal | Lucknow | Bhubaneswar | Pune | Kolkata | www.madeeasy.in

Ans. (##)

Truth table for EXOR gate

Inputs		Output
A	B	Y
0	0	0
1	1	1
1	0	1
1	1	0

Annotations:
 - Row 1: Same inputs
 - Rows 2 & 3: Different inputs
 - Row 4: Same inputs

Inputs		Output
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

If one input of EXOR gate is 0, the output is same as second input.

- (1) → (Q)
- (2) → (P)
- (3) → (S)
- (4) → (R)

Inputs		Output
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

If one output of EXOR gate is 1, the output is the complement of second input.

End of Solution

Q.12 The following excitation table is corresponding to which of the following Flip-flop?

$Q(t)$	$Q(t+1)$	Input
0	0	0
0	1	1
1	0	1
1	1	0

- (a) D-Flip-flop
- (b) JK-Flip-flop
- (c) SR-Flip-flop
- (d) T-Flip-flop

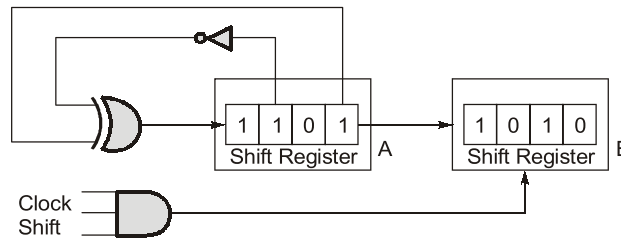
Ans. (d)

When, Input = 0
 $Q(t+1) = Q(t)$
 When, Input = 1
 $Q(t+1) = \bar{Q}(t)$

Here, the output toggle for input = 1
 So, it is a T-flip-flop.

End of Solution

Q.13 In the circuit shown, the initial binary content of shift register A is 1101 and that of shift register B is 1010. The shift register are +ve edge triggered, and gates have no delay. When the shift control is high, what will be the binary content of the shift register A and B after 4 clock pulse.



- (a) A = 1101, B = 1101 (b) A = 0101, B = 1101
(c) A = 1010, B = 1111 (d) A = 1110, B = 1001

Ans. (b)

	Register A	Register B
	1 1 0 1	1 0 1 0
Clock 1:	1 1 1 0	1 1 0 1
Clock 2:	0 1 1 1	0 1 1 0
Clock 3:	1 0 1 1	1 0 1 1
Clock 4:	0 1 0 1	1 1 0 1

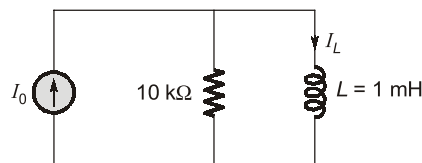
After 4th clock pulse,

$$A = 0 1 0 1$$

$$B = 1 1 0 1$$

End of Solution

Q.14 The circuit is excited by step current $I_0 u(t)$ at $t = 0^-$, I_L flows $I_L = \frac{I_0}{5}$. The minimum time taken for the current of inductor to reach 99% of its final value is _____ μs .



Ans. (0.438)

The current equation for inductor

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

$$i_L(0^+) = \frac{I_0}{5}$$

$$i_L(\infty) = I_0$$

$$i_L(t) = I_0 + \left[\frac{I_0}{5} - I_0 \right] e^{-t/\tau} = I_0 - \frac{4I_0}{5} e^{-t/\tau}$$

The inductor current reaches to 99% of its final value.

i.e.

$$i_L(t) = 0.99 I_o$$

$$0.99 I_o = I_o \left[1 - \frac{4}{5} e^{-t/\tau} \right]$$

$$\frac{4}{5} e^{-t/\tau} = 0.01$$

$$t = -\tau \ln \left(\frac{0.05}{4} \right) = 4.382\tau$$

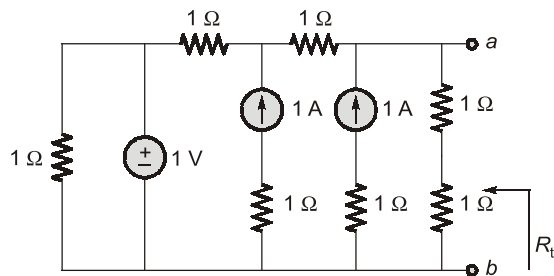
$$\tau = \frac{L}{R} = \frac{1 \times 10^{-3}}{10 \times 10^3} = 10^{-7} \text{ sec}$$

$$t = 4.382 \times 10^{-7} \text{ sec}$$

$$t = 0.4382 \mu\text{s}$$

End of Solution

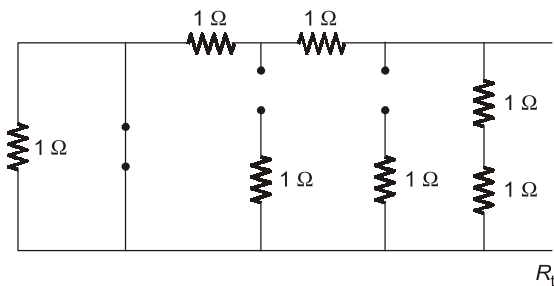
Q.15 For the circuit shown below:



The equivalent resistance R_{th} is _____.

Ans. (1)

For Thevenin resistance, we need to deactivate all the independent source.



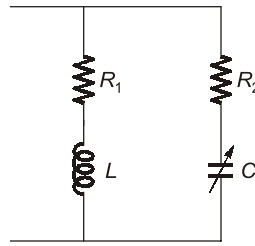
$$R_{th} = (1+1) \parallel (1+1) = 2 \parallel 2$$

$$= \frac{2 \times 2}{2+2} = \frac{4}{4} = 1 \Omega$$

$$R_{th} = 1 \Omega$$

End of Solution

Q.16 For the circuit shown below:



$$R_1 = R_2 = 2.2 \, \Omega$$

$$L = 7 \, \text{mH}$$

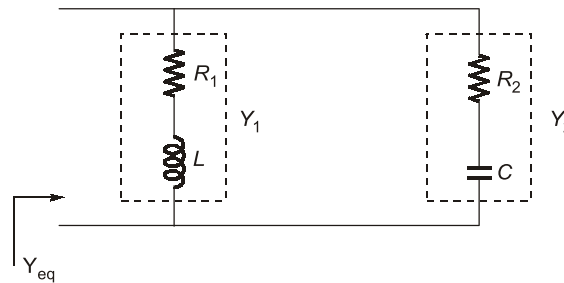
and $\omega = 100 \pi \, \text{rad/sec}$ then the value of C (in mF) is _____.

Ans. (1.45)

Given :

$$R_1 = R_2 = 2.2 \, \Omega$$

$$L = 7 \, \text{mH}, \omega = 100\pi \, \text{rad/sec}$$



$$\begin{aligned} Y_{\text{eq}} &= Y_1 + Y_2 \\ &= \frac{1}{R_1 + j\omega L} + \frac{1}{R_2 - \frac{j}{\omega C}} \\ &= \frac{(R_1 - j\omega L)}{\sqrt{R_1^2 + (\omega L)^2}} + \frac{R_2 + \frac{j}{\omega C}}{\sqrt{R_2^2 + \left(\frac{1}{\omega C}\right)^2}} \end{aligned}$$

For resonant frequency,

$$I_m\{Y_{\text{eq}}\} = 0$$

$$\frac{-j\omega L}{\sqrt{R_1^2 + (\omega L)^2}} + \frac{\frac{j}{\omega C}}{\sqrt{R_2^2 + \left(\frac{1}{\omega C}\right)^2}} = 0$$

$$\omega L \sqrt{R_2^2 + \left(\frac{1}{\omega C}\right)^2} = \frac{1}{\omega C} \sqrt{R_1^2 + (\omega L)^2}$$

$$\omega^2 L^2 \left(R_2^2 + \frac{1}{\omega^2 C^2} \right) = \frac{1}{\omega^2 C^2} (R_1^2 + \omega^2 L^2)$$

$$\omega^2 L^2 R_2^2 + \frac{L^2}{C^2} = \frac{R_1^2}{\omega^2 C^2} + \frac{L^2}{C^2}$$



Conventional Questions Practice Programme for ESE & State Services Exams

Commencing from
1st March, 2023

Teaching Hours :
300 to 350 hours

Course Duration :
100 days

**OFFLINE
& ONLINE
COURSE**

Streams :
CE, ME, EE, EC

Key Features

- ✓ In-depth discussion on conventional questions.
- ✓ Beneficial to develop numerical question-solving techniques.
- ✓ Helps to improve answer writing & presentation skills.
- ✓ Discussion on probable questions.
- ✓ Updated Mains workbook with wide range of practice questions.
- ✓ ESE Mains test series will be conducted on every Sunday in synchronization with the subjects.

Note : Offline classes will be conducted at Delhi Centre.

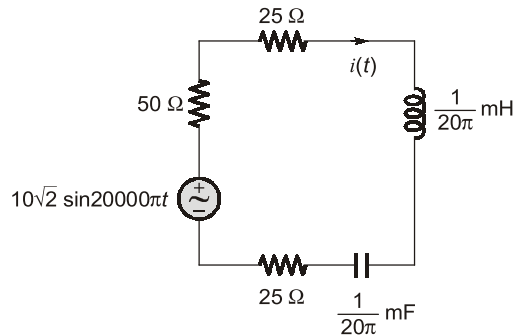
Delhi Centre : 44 - A/1, Kalu Sarai, Near Hauz Khas Metro Station, New Delhi - 110016 | **Ph :** 9021300500

MADE EASY Centres : Delhi | Hyderabad | Jaipur | Bhopal | Lucknow | Bhubaneswar | Pune | Kolkata | www.madeeasy.in

$$\begin{aligned}\omega^2 L^2 R_2^2 &= \frac{R_1^2}{\omega^2 C^2} \\ C^2 &= \frac{R_1^2}{R_2^2} \cdot \frac{1}{\omega^4 L^2} \\ C &= \frac{R_1}{R_2} \cdot \frac{1}{\omega^2 L} \\ &= \frac{2.2}{2.2} \times \frac{1}{(100\pi)^2 \times 7 \times 10^{-3}} \\ C &= 1.45 \times 10^{-3} \text{ F}\end{aligned}$$

End of Solution

Q.17 For the circuit shown below:



rms value of $i(t)$ is _____.

Ans. (0.1)

The resonant frequency,

$$\begin{aligned}\omega_0 &= \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{\frac{1}{20\pi} \times 10^{-3} \times \frac{1}{20\pi} \times 10^{-3}}} \\ &= 20\pi \times 10^3 \text{ rad/sec} \\ \omega_0 &= 20000\pi \text{ rad/sec}\end{aligned}$$

Hence, the circuit is under resonance.

So, the total current,

$$\begin{aligned}i(t) &= \frac{10\sqrt{2} \angle 0^\circ}{50 + 25 + 25} \\ &= 0.1\sqrt{2}\end{aligned}$$

$$\text{RMS value of } i(t) = \frac{0.1\sqrt{2}}{\sqrt{2}} = 0.1 \text{ A}$$

$$i(t)|_{\text{rms}} = 0.1 \text{ Amp}$$

End of Solution

Q.18 Force per unit length between two infinitely long parallel conductors, with a gap of 2 cm between them is $10 \mu\text{N/m}$, when the gap is doubled, then force per unit length will be _____ $\mu\text{N/m}$.

Ans. (5)

We know that,

Force is inversely proportional to 'd'

$$F \propto \frac{1}{d}$$

$$\frac{F_1}{F_2} = \frac{d_2}{d_1}$$

$$\frac{10}{F_2} = \frac{4 \text{ cm}}{2 \text{ cm}}$$

$$F_2 = \frac{10}{2} = 5 \mu\text{N/m}$$

End of Solution

Q.19 If $f(x) = x \sin\left(\frac{1}{x}\right)$; then $\lim_{x \rightarrow 0} f(x) = ?$

Ans. (0)

$$\lim_{x \rightarrow 0} x \sin \frac{1}{x} = \lim_{x \rightarrow 0} \frac{\sin \frac{1}{x}}{\frac{1}{x}}$$

$$\lim_{y \rightarrow \infty} \frac{\sin y}{y} = \frac{\text{finite}}{\infty} = 0$$

End of Solution

Q.20 If $f(z) = i \frac{1-z}{1+z}$ then $f^{-1}(z)$ maps real axis to

- (a) unit circle with center not at origin
- (b) real axis
- (c) imaginary axis
- (d) unit circle with center at origin

Ans. (d)

Given :

$$w = u + iv = \frac{i(1-z)}{(1+z)}$$

$$= \frac{i - iz - i^2 y}{1+x+iy}$$

$$= \frac{i(1-x)+y}{(1+x)+iy} \times \frac{(1+x)-iy}{(1+x)-iy}$$

$$u + iv = \frac{y(1-x)+y(1+x)}{(1+x)^2+y^2} + i \frac{(1-x^2)-y^2}{(1+x)^2+y^2}$$

To find image of real axis is w -plane.

We take $V = 0$

$$\Rightarrow \frac{(1-x^2)-y^2}{(1+x)^2+y^2} = 0$$

$$\Rightarrow 1 - x^2 - y^2 = 0$$

$$\Rightarrow x^2 + y^2 = 1$$

\therefore Under the mapping of $f^{-1}(z)$ real axis in w -plane maps to unit circle in z -plane.

End of Solution

Q.21 $A = \begin{bmatrix} 1 & 4 \\ -3 & \alpha \\ \beta & 6 \end{bmatrix}$ If Rank of matrix A is 1 then the ratio of $\frac{\alpha}{\beta}$ is _____.

Ans. (-8)

Given : $\rho(A_{3 \times 2}) = 1$

So, $C_2 = KC_1$

$\Rightarrow 4 = K(1)$

$\Rightarrow K = 4$

Also, $\alpha = -3K$ and $6 = K\beta$

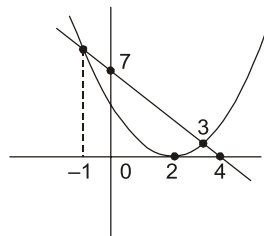
$$\therefore \frac{\alpha}{\beta} = -\frac{1}{2}K^2 = -\frac{1}{2} \times 4^2 = -8$$

End of Solution

Q.22 $g(x) = \max\{(x-2)^2, -2x+7\}; x \in (-\infty, \infty)$. Minimum value of $g(x) =$ _____.

Ans. (1)

$$g(x) = \max\{(x-2)^2, -2x+7\}$$





Rank Improvement Course for **GATE 2024**

Commencing from
1st May, 2023

Teaching Hours :
300 to 350 hours

Course Validity :
Till GATE 2024 Exam

**LIVE-ONLINE
COURSE**

Streams :
CE, ME, EE, EC, CS

Key Features

- ✓ Comprehensive problem-solving sessions by India's top faculties.
- ✓ Focus on improving accuracy & speed.
- ✓ Practice all types of questions to brush up on your concepts.
- ✓ Newly develop workbooks (e-copy) in line with recent trends in GATE.
- ✓ Highly useful for repeaters candidates.

**Download
the App**



Android

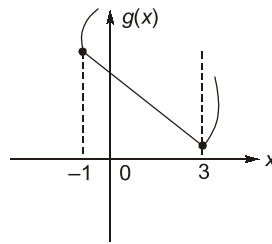


iOS

 **9021300500**

 **www.madeeasyprime.com**

Then $g(x)$



From the figure:

Minimum value of $g(x)$ is at

$$x = 3$$

\therefore

$$\begin{aligned} g_{\min}(x) &= g(3) \\ &= (3 - 2)^2 \text{ or } (-2x + 7)_{x=3} \\ &= 1 \end{aligned}$$

End of Solution

Q.23 If X is a discrete random variable

X	0	1	2
P	0.25	0.5	?

then value of $[E(X) - E(X^2)] = \underline{\hspace{2cm}}$.

Ans. (-0.5)

x is discrete R.V

W.K.T:
$$\sum_{i=1}^n P(x = x_i) = 1$$

$$\Rightarrow 0.25 + 0.5 + k = 1$$

$$\Rightarrow k = 1 - 0.75$$

$$k = 0.25$$

\therefore

$$\begin{aligned} E(x) &= \sum_i x_i P_i \\ &= 0 \times 0.25 + 1 \times 0.5 + 2 \times 0.25 \\ &= 0.5 + 0.5 \end{aligned}$$

$$E(x) = 1$$

$$\begin{aligned} E(x^2) &= \sum_i x_i^2 P_i \\ &= 0^2 \times 0.25 + 1^2 \times 0.5 + 2^2 \times 0.25 \\ &= 0 + 0.5 + 1 \end{aligned}$$

$$E(x^2) = 1.5$$

$$\therefore E(x) - E(x^2) = 1 - 1.5 = -0.5$$

End of Solution

Q.24 Choose solution 'S' for set of equations

$$x - 2y + z = 0$$

$$x - z = 0$$

(a) $S = \left\{ \alpha \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} + \beta \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix} \mid \alpha, \beta \in R \right\}$

(b) $S = \left\{ \alpha \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} \mid \alpha \in R \right\}$

(c) $S = \left\{ \alpha \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} + \beta \begin{pmatrix} 2 \\ 1 \\ 1 \end{pmatrix} \mid \alpha, \beta \in R \right\}$

(d) $S = \left\{ \alpha \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix} \mid \alpha \in R \right\}$

Ans. (b)

Given : $x - 2y + z = 0$

$$x - z = 0$$

Solution is given by solving also equations.

	x	y	z	
-2	1	1	-2	
0	-1	1	0	

$$\frac{x}{2} = \frac{y}{2} = \frac{z}{2} = K$$

$\Rightarrow x = K, y = K, z = K$

$\therefore \begin{bmatrix} x \\ y \\ z \end{bmatrix} = K \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}, K \in R$

End of Solution

Q.25 In a P-i-n photodiode, a pulse of light containing 8×10^{12} incident photons at wavelength $\lambda_0 = 1.55 \mu\text{m}$ gives rise to an average 4×10^{12} electrons collected at the terminals of the device. The quantum efficiency of the photodiode at its wavelength is _____%.

(a) 54.2

(b) 62.5

(c) 80

(d) 50

Ans. (d)

$$\text{quantum efficiency, } \eta = \frac{\text{Electrons out}}{\text{Photons incident}} = \frac{4 \times 10^{12}}{8 \times 10^{12}} = 0.5$$

$\therefore \eta = 50\%$

End of Solution

- Q.26** LED is operated under _____ and photodiode is operated under _____.
- Forward biased and Reverse biased
 - Forward biased and Forward biased
 - Reverse biased and Reverse biased
 - Reverse biased and Forward biased

Ans. (a)

End of Solution

- Q.27** A silica glass fibre has a core refractive index of 1.47 and a cladding refractive index of 1.44. If the cladding is completely stripped out and core is dipped in water having a refractive index of 1.33, the numerical aperture of modified fiber is _____.

Ans. (0.62)

$$\begin{aligned} \text{Numerical Aperture, N.A} &= \sqrt{n_{\text{core}}^2 - n_{\text{water}}^2} \\ &= \sqrt{1.47^2 - 1.33^2} \\ \text{N.A} &= 0.62 \end{aligned}$$

End of Solution

- Q.28** Number of times Nyquist plot of $G(s)H(s) = \frac{(s-1)(s-2)}{2(s+1)(s+2)}$ encircles the origin is _____.

Ans. (2)

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

∴ Number of poles which are in RHS, $P = 0$

Number of zeros which are in RHS, $Z = 2$

(Here it is asking for number of encirclement around the origin).

$$\begin{aligned} \therefore \text{Encirclement, } N &= P - Z \\ &= 0 - 2 \\ N &= -2 \end{aligned}$$

∴ 2 clockwise encirclement.

End of Solution

Q.29 Number of zeros of $s^3 + 2s^2 + 5s + 80$ in right half plane is ____.

Ans. (2)

$$s^3 + 2s^2 + 5s + 80$$

Forming RH array

s^3	1	5
s^2	2	80
s^1	$\frac{10-80}{2} = -35$	
s^0	80	

\therefore There are two sign change.
Hence, 2 open loop zeros in RHS.

End of Solution

Q.30 If $G(s) = \frac{2(1-s)}{(1+s)^2}$ then phase margin of $G(s) =$ _____ degree.

Ans. (0)

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

Phase margin is calculated at gain crossover frequency ω_{gc} .
 ω_{gc} is the frequency at which the magnitude of $G(j\omega)H(j\omega)$ is 1.

$$|G(j\omega)H(j\omega)|_{\omega=\omega_{gc}} = \frac{2\sqrt{1+\omega_{gc}^2}}{(1+\omega_{gc}^2)} = \frac{2}{\sqrt{1+\omega_{gc}^2}} = 1$$

$$2 = \sqrt{1+\omega_{gc}^2}$$

$$4 = 1 + \omega_{gc}^2$$

$$\omega_{gc} = \sqrt{3} \text{ rad/sec}$$

Now ϕ at $\omega_{gc} = \tan^{-1}[-\omega_{gc}] - 2 \tan^{-1}[\omega_{gc}]$

$$= -3 \tan^{-1}[\omega_{gc}]$$

$$= -3 \tan^{-1}(\sqrt{3})$$

$$= -180^\circ$$

\therefore Phase margin = $180 + \phi$ at ω_{gc}

$$= 180^\circ - 180^\circ = 0^\circ$$

End of Solution



Live-Online Classes for **SSC-JE 2023**

Batches are live

Validity: **Till 31st July, 2023**

**TECHNICAL &
NON-TECHNICAL
SYLLABUS**

Streams :
CE, ME, EE

Course Details

CE Only Technical	ME Only Technical	EE Only Technical	Non-Tech (RA + GS)
Teaching Hrs : 650 Hrs	Teaching Hrs : 450 Hrs	Teaching Hrs : 300 Hrs	Teaching Hrs : 260 Hrs
Total No. of Books : 16	Total No. of Books : 15	Total No. of Books : 10	Total No. of Books : 03

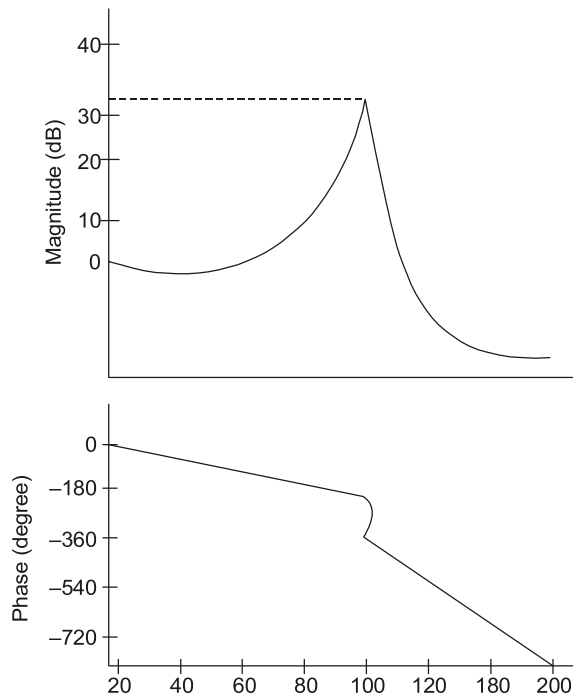
Key Features

- ✓ Live Classes by experienced and renowned faculties having experience in SSC-JE field.
- ✓ Systematic subject sequence for Paper-I and Paper-II.
- ✓ Comprehensive coverage of Technical & Non-technical syllabus for Prelims & Mains.
- ✓ Well-researched study materials.
- ✓ Facility of watching video thrice, i.e., 1 Live session + 2 Recorded sessions.

📞 **9021300500**

🌐 **www.madeeasyprime.com**

Q.31 Magnitude and phase plot shown in figure. Match with the transfer function.



- | | |
|--|--------------------------------------|
| (a) $\frac{10000}{s^2 + 2s + 10000} e^{-0.5 \times 10^{-12}s}$ | (b) $\frac{10000}{s^2 + 2s + 10000}$ |
| (c) $\frac{10000}{s^2 + 2s + 10000} e^{-0.05s}$ | (d) $\frac{100}{s^2 + 2s + 100}$ |

Ans. (c)

From the figure it is clear that there should be phase lag.
Hence, option (a) and (c) could be answer.

From the figure, at $\omega = 100$ rad/sec, Phase is -360° .

Now considering option (c) only delay element

$$e^{-0.05s} = e^{-0.05 \times 100j} = e^{-j5}$$

Hence, phase is $= -5$ radians $= -286.5^\circ$

and from the rest of transfer function $\frac{1000}{s^2 + 2s + 10000}$

at $\omega = \omega_n = 100$ rad/sec phase is -90° .

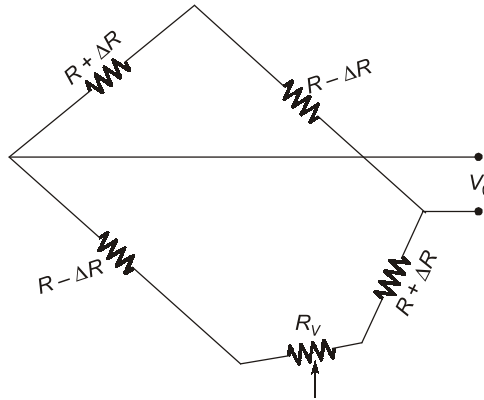
$$= -286.5 - 90^\circ$$

$$= -376.5^\circ$$

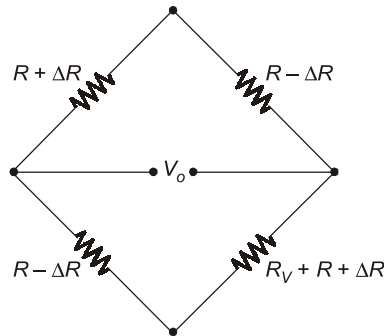
Hence, option (c) satisfy the graph.

End of Solution

Q.32 Initially bridge was balanced and after applying force resistances are changed then find minimum value of R_V to balance the bridge.



Ans. (##)



$$V_o = E \left[\frac{R + \Delta R}{R + \Delta R + R - \Delta R} - \frac{R - \Delta R}{R - \Delta R + (R_V + R + \Delta R)} \right]$$

$$V_o = E \left[\frac{R + \Delta R}{2R} - \frac{R - \Delta R}{2R + R_V} \right]$$

For a balanced bridge $\Rightarrow V_b = 0$

$$0 = E \left[\frac{R + \Delta R}{2R} - \frac{R - \Delta R}{2R + R_V} \right]$$

$$\frac{R + \Delta R}{2R} = \frac{R - \Delta R}{2R + R_V} \Rightarrow 2R + R_V = 2R \left[\frac{R - \Delta R}{R + \Delta R} \right]$$

$$R_V = 2R \left[\frac{R - \Delta R}{R + \Delta R} - 1 \right] = 2R \left[\frac{R - \Delta R - R - \Delta R}{R + \Delta R} \right]$$

$$= 2R \left[-\frac{2\Delta R}{R + \Delta R} \right] = \frac{-4R\Delta R}{R \left[1 + \frac{\Delta R}{R} \right]} = -\frac{4\Delta R}{1 + \frac{\Delta R}{R}} \quad \left(\frac{\Delta R}{R} \text{ neglected} \right)$$

$$= -4\Delta R \Rightarrow \text{minimum value}$$

End of Solution

Q.33 The Laplace transform of the continuous time signal $x(t) = e^{-3t}u(t - 5)$ is _____. $u(t)$ denotes the continuous time unit step signal.

- (a) $\frac{e^{-5(s-3)}}{s-3}, \text{Real}\{s\} > -3$ (b) $\frac{e^{-5(s+3)}}{s+3}, \text{Real}\{s\} > -3$
(c) $\frac{e^{-5(s-3)}}{s+3}, \text{Real}\{s\} > -3$ (d) $\frac{e^{-5s}}{s+3}, \text{Real}\{s\} > -3$

Ans. (b)

We have, $x(t) = e^{-3t}u(t - 5)$

We know, $u(t) \rightarrow \frac{1}{s}$

$$u(t - 5) \rightarrow \frac{1}{s} \cdot e^{-5s}$$

$$e^{-3t}u(t - 5) \rightarrow \frac{1}{(s+3)} \cdot e^{-5(s+3)}$$

$$\therefore X(s) = \frac{e^{-5(s+3)}}{s+3}; \quad \text{Re}(s) > -3$$

End of Solution

Q.34 If $y(t) = x(4t)$ where $x(t)$ is a continuous time periodic signal with fundamental period of 100 sec, then the fundamental period of $y(t)$ is _____ sec.

Ans. (25)

Let $x(t) = \sin(\omega_o t)$

We have, $T = 100 \text{ sec}$

$$\omega_o = \frac{2\pi}{T} = \frac{2\pi}{100} \text{ rad/sec}$$

Now, $y(t) = x(4t) = \sin(4\omega_o t)$

$$\therefore \omega' = 4\omega_o = 4 \times \frac{2\pi}{100}$$

$$\frac{2\pi}{T'} = 4 \times \frac{2\pi}{100}$$

$$T' = 25 \text{ sec}$$

End of Solution



Live-Online Course for **General Studies** for **State Engineering** and **SSC Exams**

**FULL
FLEDGED
COURSE FOR
GENERAL
STUDIES**

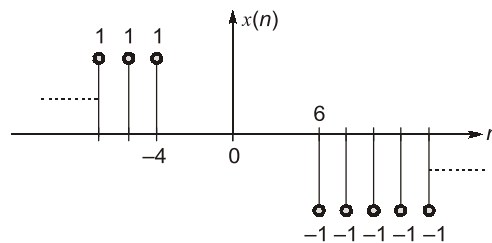
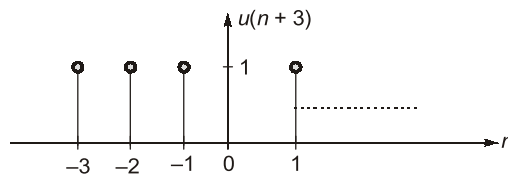
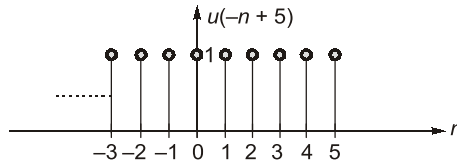
Subject Covered : History, General Science, Polity, Environment, Geography, General Knowledge, Economy & Current Affairs

Duration : 3 Months | **Validity :** 6 Months

Batches commencing from **22nd Feb, 2023**

Key Features

- ✓ 250 Hrs of quality teaching by renowned teachers of MADE EASY.
- ✓ Printed study material will be dispatched to your address.
- ✓ Comprehensive coverage as per latest syllabus and trends of various competitive exams.



Smallest 'n' for which $x[n] = 0$
 $\therefore n = -3$

End of Solution

Q.37 The impulse response of an LTI system is $h(t) = \delta(t) + 0.5\delta(t - 4)$, where $\delta(t)$ is the continuous time unit impulse signal. If the input signal $x(t) = \cos\left(\frac{7\pi}{4}t\right)$ then output is

- (a) $0.5\sin\left(\frac{7\pi}{4}t\right)$ (b) $1.5\sin\left(\frac{7\pi}{4}t\right)$
 (c) $0.5\cos\left(\frac{7\pi}{4}t\right)$ (d) $1.5\cos\left(\frac{7\pi}{4}t\right)$

Ans. (c)

We have; $h(t) = \delta(t) + 0.5\delta(t - 4)$
 Taking FT;

$$H(\omega) = 1 + 0.5e^{-j4\omega}$$

at $\omega = \frac{7\pi}{4}$

$$\begin{aligned} H(\omega) &= 1 + 0.5e^{-j4\left(\frac{7\pi}{4}\right)} \\ &= 1 + 0.5e^{-j7\pi} \\ &= 0.5 \end{aligned}$$

Q.39 If $F(z) = \frac{1}{1-z}$ expanded as power series around $z = 2$ would result in $f(z) = \sum_{k=0}^{\infty} a_k(z-2)^k$

with region of convergence $|z - 2| < 1$ then value of a_k is

(a) $\left(\frac{1}{2}\right)^k$

(b) $(-1)^k$

(c) $(-1)^{k+1}$

(d) $\left(\frac{1}{z}\right)^{k+1}$

Ans. (c)

Power series expansion for

$$\frac{1}{1+x} = 1 - x + x^2 - x^3 + x^4 - \dots \text{ when } |x| < 1$$

Now, given that,
$$F(z) = \frac{1}{1-z} = -\left[\frac{1}{1+(z-2)}\right]$$

$$= -[1 - (z-2) + (z-2)^2 - (z-2)^3 + \dots], \text{ when } |z-2| < 1$$

$$= -\sum_{K=0}^{\infty} (-1)^K (z-2)^K, \quad |z-2| < 1$$

$$= \sum_{K=0}^{\infty} (-1)^{K+1} (z-2)^K, \quad |z-2| < 1$$

$$= \sum_{K=0}^{\infty} a_K (z-2)^K, \quad |z-2| < 1$$

$$\therefore a_K = (-1)^{K+1}$$

End of Solution

