Date : .....

A CONSOLIDATED QUESTION PAPER-CUM-ANSWER BOOKLET

IMS™ (INSTITUTE OF MATHEMATICAL SCIENCES)

MAINS TEST SERIES-2019

(JUNE-2019 *to* SEPT.-2019)

Under the guidance *of* K. Venkanna

MATHEMATICS

PAPER - II : MODERN ALGEBRA, REAL ANALYSIS, COMPLEX & LPP

TEST CODE: TEST-2: IAS(M)/16-JUNE.-2019

Time: 3 Hours **Maximum Marks: 250**

INSTRUCTIONS

1. This question paper-cum-answer booklet has **50** pages and has **33 PART/SUBPART** questions. Please ensure that the copy of the question paper-cum-answer booklet you have received contains all the questions.
2. Write your Name, Roll Number, Name of the Test Centre and Medium in the appropriate space provided on the right side.
3. A consolidated Question Paper-cum-Answer Booklet, having space below each part/sub part of a question shall be provided to them for writing the answers. Candidates shall be required to attempt answer to the part/sub-part of a question strictly within the pre-defined space. Any attempt outside the pre-defined space shall not be evaluated. ''
4. Answer must be written in the medium specified in the admission Certificate issued to you, which must be stated clearly on the right side. No marks will be given for the answers written in a medium other than that specified in the Admission Certificate.
5. Candidates should attempt Question Nos. 1 and 5, which are compulsory, and any **THREE** of the remaining questions selecting at least **ONE** question from each Section.
6. The number of marks carried by each question is indicated at the end of the question. Assume suitable data if considered necessary and indicate the same clearly.
7. Symbols/notations carry their usual meanings, unless otherwise indicated.
8. All questions carry equal marks.
9. All answers must be written in blue/black ink only. Sketch pen, pencil or ink of any other colour should not be used.
10. All rough work should be done in the space provided and scored out finally.
11. The candidate should respect the instructions given by the invigilator.
12. The question paper-cum-answer booklet must be returned in its entirety to the invigilator before leaving the examination hall. Do not remove any

READ INSTRUCTIONS ON THE LEFT SIDE OF THIS PAGE CAREFULLY

Name

Roll No.

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Medium

Do not write your Roll Number or Name anywhere else in this Question Paper-cum-Answer Booklet.

I have read all the instructions and shall abide by them

Signature of the Candidate

I have verified the information filled by the candidate above

Signature of the invigilator

IMPORTANT NOTE:

Whenever a question is being attempted, all its parts/ sub-parts must be attempted contiguously. This means that before moving on to the next question to be attempted, candidates must finish attempting all parts/ sub-parts of the previous question attempted. This is to be strictly followed. Pages left blank in the answer-book are to be clearly struck out in ink. Any answers that follow pages left blank may not be given credit.

P.T.O.

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INDEX TABLE

QUESTION	No.	PAGE NO.	MAX. MARKS	MARKS OBTAINED
1	(a)			
	(b)			
	(c)			
	(d)			
	(e)			
2	(a)			
	(b)			
	(c)			
	(d)			
3	(a)			
	(b)			
	(c)			
	(d)			
4	(a)			
	(b)			
	(c)			
	(d)			
5	(a)			
	(b)			
	(c)			
	(d)			
	(e)			
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	(d)			
7	(a)			
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	(d)			
8	(a)			
	(b)			
	(c)			
	(d)			
Total Marks				

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SECTION – A

1. (a) Are the following groups cyclic groups ? Give reasons.

(i) The Klein 4-group.

(ii) The dihedral group D_4.

(iii) The group of all roots (real or complex) of the equation $x^n - 1 = 0$.

(iv) The group Q^* of non-zero rationals, for multiplication. **[10]**

1. (b) Let R be a commutative ring with unit element whose only ideals are (0) and R itself. Then R is a field. **[10]**

1. (c) For $u_1 > 0$, the sequence u_n defined by

$$u_{n+1} = 1 + \frac{1}{u_n} \forall n, \text{ converges to} \left(\frac{\sqrt{5}+1}{2} \right)$$ **(10)**

1. (d) Prove that the function $u = e^{-x}$ (x cos y + y sin y). is harmonic and find the corresponding analytic function. **(10)**

1. (e) Write the dual of the problem.

Min $Z = 2x_2 + 5x_3$

Subject to $x_1 + x_2 \geq 2$

$2x_1 + x_2 + 6x_3 \leq 6$

$x_1 - x_2 + 3x_3 = 4$

$x_1, x_2, x_3 \geq 0.$ **[10]**

2. (a) (i) Show that every subgroup of an abelian group is normal.

(ii) Is the converse of Problem (i) true ? If yes, prove it, if no, give an example of a non-abelian group all of whose subgroups are normal. **[12]**

2. (b) Suppose that N and M are two normal subgroups of G and that $N \cap M = (e)$. show that for any $n \in N$, $m \in M$, $nm = mn$. **[08]**

2. (c) Test the convergence of

(i) $\int_0^1 \frac{dx}{\sqrt{1-x^3}}$

(ii) Prove that the integral $\int_0^\infty x^{m-1}e^{-x}dx$ is convergent if and only if $m > 0$. **[15]**

2. (d) Apply the method of contour integration to prove that

$$\int_0^{2\pi} \frac{\cos 2\theta}{5+4\cos\theta}\,d\theta = \frac{\pi}{6}.$$ **[15]**

3. (a) Prove, by an example, that we can find three groups $E \subset F \subset G$, where E is normal in F, F is normal in G, but E is not normal in G.

[10]

3. (b) Given an example of an integral domain which has an infinite number of elements, yet is of finite characteristic. **[10]**

3. (c) Suppose that f is defined on $I = \{x : 0 \le x \le 1\}$ by the formula

$$f(x) = 0 \begin{cases} \dfrac{1}{2^n} & \text{if } x = \dfrac{j}{2^n} \text{ where } j \text{ is an odd integer} \\ & \text{and } 0 < j < 2^n, n = 1, 2, ..., \\ 0 & \text{otherwise.} \end{cases}$$

Determine whether or not f is integrable and prove your result. **[15]**

3. (d) Using simplex method solve the L.P. problem.

Mini $Z = 4x_1 + 8x_2 + 3x_3$

subject to $x_1 + x_2 \geq 2$

$2x_1 + x_3 \geq 5$

$x_1, x_2, x_3 \geq 0.$ **[15]**

4. (a) Let M_1 and M_2 be distinct maximal ideals of R. Show that $M_1 + M_2 = R$. Define a suitable ring homomorphism of R onto $R/M_1 \times R/M_2$ and deduce that $R/M_1 \cap M_2 \simeq R/M_2 \times R/M_2$. **[15]**

4. (b) The function f(x) = 1/x is continuous on (0, 1) but not uniformly continuous. **[13]**

4. (c) (i) Specify the nature of singularity at $z = -2$ of

$$f(z) = (z-3)\sin\frac{1}{z+2}$$

(ii) Find zeros and poles of $\left(\frac{z+1}{z^2+1}\right)^2$ **[12]**

4. (d) An automobile dealer wishes to put four repairmen to four different jobs. The repairmen have somewhat different kinds of skills and they exhibit different levels of efficiency from one job to another. The dealer has estimated the number of manhours that would be required for each job-man combination. This is given in the matrix form in adjacent table. Find the optimum assignment that will result in minimum manhours needed.

Job / Man	A	B	C	D
1	5	3	2	8
2	7	9	2	6
3	6	4	5	7
4	5	7	7	8

[10]

SECTION – B

5. (a) Give an example of a group which is not a cyclic group, but every proper subgroup of which is cyclic. **[10]**

5. (b) Consider the following rings R and R′ with four elements

$R = \{a, b, c, d\}$ with $+$ and $\bullet$ defined by

$+$	a	b	c	d
a	a	b	c	d
b	b	a	d	c
c	c	d	a	b
d	d	c	b	a

$\bullet$	a	b	c	d
a	a	a	a	a
b	a	b	a	b
c	a	a	c	c
d	a	b	c	d

and $R' = \{x, y, z, t\}$ with $+$ and $\bullet$ defined by

$+$	x	y	z	t
x	x	y	z	t
y	y	z	t	x
z	z	t	x	y
t	t	x	y	z

$\bullet$	x	y	z	t
x	x	x	x	x
y	x	y	z	t
z	x	z	x	z
t	x	t	z	y

Investigate whether R and R′ are isomorphic. **[10]**

5. (c) The sequence $nx/(1 + n^2 x^2)$ is not uniformly convergent over **R** but it is uniformly convergent on $\{x : |x| > k > 0\}$. **[10]**

5. (d) If $f(z)=\frac{x^3y(y-ix)}{x^6+y^2}, z\neq 0$ and f(0) = 0, show that $\frac{f(z)-f(0)}{z}\to 0$ as $z\to 0$ along any radius vector but not as $z \to 0$ in any manner. **[10]**

5. (e) A firm plans to purchase at least 200 quintals of scrap containing high quality metal X and low quality metal. Y. It decides that the scrap to be purchased must contain at least 100 quintals of X-metal and not more than 35 quintals of Y-metal. The firm can purchase the scrap from two suppliers (A and B) in unlimited quantities. The percentage of X and Y metals in terms of weight in the scraps supplied by A and B is given below :

Metals	supplier A	Supplier B
X	25%	75%
Y	10%	20%

The price of A's scrap is Rs. 200 per quintal and that of B's is Rs. 400 per quintal. Formulate this problem as LP model and solve it graphically to determine the quantities that the firm should buy from the two suppliers so as to minimize total purchase cost. **[10]**

6. (a) (i) Let G be the group of all 2×2 matrices $\begin{pmatrix} a & b \\ c & d \end{pmatrix}$ where a, b, c, d are integers modulo p, p a prime number, such that $ad - bc \neq 0$. G forms a group relative to matrix multiplication. What is $o(G)$?

(ii) Let H be the subgroup of the G of part (a) defined by

$$H = \left\{ \begin{pmatrix} a & b \\ c & d \end{pmatrix} \in G \,\middle|\, ad - bc = 1 \right\}.$$

What is $o(H)$? **[15]**

6. (b) Investigate whether the following ideals are (i) prime ideals, (ii) maximal ideals in the ring R.

(i) $R = Z_6$ and $I = \{\overline{0}, \overline{2}, \overline{4}\}$.

(ii) R = 2Z and I = 4Z

(iii) R = C[0, 1] the ring of continuous functions on [0, 1] and $I = \left\{x \mid x\left(\frac{1}{2}\right) = 0\right\}$. **[15]**

6. (c) Prove that every integral domain can be imbedded in a field. **[20]**

7. (a) Prove that the following sets are bounded

$$\left\{n^{1/n} : n \in N\right\}, \left\{\left(1+\frac{1}{n}\right)^n : n \in N\right\}, \ \{a^{1/n} : a > 0 \text{ and } n \in N\}.$$

Give supremum and infimum of each of these sets. **[08]**

7. (b) Show that $\prod_{1}^{\infty}\left(1-\frac{1}{4n^2}\right)$ converges and its limit lies between $\frac{1}{2}$ and 1. **[10]**

7. (c) For $x > -1$, test for convergence

$$1+\frac{2^2}{3.4}x+\frac{2^2.4^2}{3.4.5.6}x^2+\frac{2^2.4^2.6^2}{3.4.5.6.7.8}x^3+....$$ **[15]**

7. (d) Let a function $f : \mathbf{R} \to \mathbf{R}$ satisfy the equation
$f(x + y) = f(x) + f(y)$, $\forall$ x, y $\in$ **R**. Show that

(i) If *f* is continuous at the point x = a, then it is continuous for all x $\in$ **R**.

(ii) If *f* is continuous then f(x) = kx, for some constant k. **[15]**

8. (a) Using Cauchy's/Cauchy's integral formula.

(i) Evaluate $\oint_C \frac{\sin 3z}{z+\pi/2} dz$ if c is the circle $|z| = 5$.

(ii) Evaluate $\oint_C \frac{e^{3z}}{z-\pi i} dz$ if C is : (A) the circle $|z-1| = 4$, (B) the ellipse $|z-2| + |z+2| = 6$. **[10]**

8. (b) Find the Laurent expansion of $\frac{z}{(z+1)(z+2)}$ about the singularity $z = -2$. Specify the region of convergence. **[07]**

8. (c) By integrating $e^{iz} / (z - ai)$, $(a > 0)$ round a suitable contour, prove that

$$\int_{-\infty}^{\infty} \frac{a\cos x + x\sin x}{x^2 + a^2} dx = 2\pi e^{-a} .$$ **[13]**

8. (d) Solve the following transportation problem

		To			Available
From		2	7	4	5
		3	3	1	8
		5	4	7	7
		1	6	2	14
Required		7	9	18	34

[20]

ROUGH SPACE

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