Date : .....

A CONSOLIDATED QUESTION PAPER-CUM-ANSWER BOOKLET

IMS™ (INSTITUTE OF MATHEMATICAL SCIENCES)

MAINS TEST SERIES-2020

(JULY *to* DEC.-2020)

IAS/IFoS

MATHEMATICS

Under the guidance *of* K. Venkanna

PDE, NUMERICAL ANALYSIS & COMP. PROG. AND MECHANICS & FD

TEST CODE: TEST-4: IAS(M)/02-AUG.-2020

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

INSTRUCTIONS

1. This question paper-cum-answer booklet has 50 pages and has **31 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 page from this booklet.

READ INSTRUCTIONS ON THE LEFT SIDE OF THIS PAGE CAREFULLY

Name

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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)			
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5	(a)			
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	(d)			
	(e)			
6	(a)			
	(b)			
	(c)			
	(d)			
7	(a)			
	(b)			
	(c)			
	(d)			
8	(a)			
	(b)			
	(c)			
	(d)			
Total Marks				

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SECTION – A

1. (a) Show that the differential equation of all cones which have their vertex at the origin is $px + qy = z$. Verify that $yz + zx + xy = 0$ is a surface satisfying the above equation. **[10]**

1. (b) Solve $(D^2 - DD' - 2D'^2)\, z = (2x^2 + xy - y^2) \sin xy - \cos xy$. **[10]**

1. (c) By using Newton's forward interpolation formula, find the number of men getting wages between Rs. 10 and 15 from the following date. **[10]**

Wages in Rs.	0 – 10	10 – 20	20 – 30	30 – 40
No. of Men	9	30	35	42

1. (d) Give a Boolean expression for the following statements:

(i) Y is a 1 only if A is a 1 and B is a 1 or if A is a 0 and B is a 0.

(ii) Y is a 1 only if A, B and C are all 1s or if only one of the variables is a 0. **[10]**

1. (e) Find the M.I. of a right solid cone of mass M, height h and radius of whose base is a, about its axis. **[10]**

2. (a) The ends A and B of a rod, 10 cm in length, are kept at temperatures 0°C and 100°C until the steady state condition prevails. Suddenly the temperature at the end A is increased to 20°C, and the end B is decreased to 60° C. Find the temperature distribution in the rod at time t. **[20]**

2. (b) Find the solution of the following system of equations

$$x_1 - \frac{1}{4}x_2 - \frac{1}{4}x_3 = \frac{1}{2}$$

$$-\frac{1}{4}x_1 + x_2 - \frac{1}{4}x_4 = \frac{1}{2}$$

$$-\frac{1}{4}x_1 + x_3 - \frac{1}{4}x_4 = \frac{1}{4}$$

$$-\frac{1}{4}x_2 - \frac{1}{4}x_3 + x_4 = \frac{1}{4}$$

using Gauss-Seidel method and perform the first five iterations. **[15]**

2. (c) Two equal rods AB and BC, each of length l smoothly joined at B are suspended from A and oscillate in a vertical plane through A. Show that the periods of normal oscillations are $\frac{2\pi}{n}$, where $n^2 = \left(3 \pm \frac{6}{\sqrt{7}}\right)\frac{g}{l}$. **[15]**

3. (a) Find the characteristic of the equation $z = (1/2)(p^2 + q^2) + (p - x)(q - y)$ and determine the integral surface which passes through the x-axis. **[18]**

3. (b) Solve the following differential equation $\frac{dy}{dx} = x + y$ with the initial condition y(0) = 1, using fourth-order Runge-Kutta method from x = 0 to x = 0.4 taking h = 0.1. **[16]**

3. (c) Steam is rushing from a boiler through a conical pipe, the diameters of the ends of which are D and d; if V and v be the corresponding velocities of the stream, and if the motion be supposed to be that of divergence from the vertex of the cone, prove that $\frac{v}{V} = \frac{D^2}{d^2} e^{\left(v^2 - V^2\right)/2k}$ where k is the pressure divided by the density and supposed to be constant. **[16]**

4. (a) Find the integral surface of the partial differential equation $(x - y)p + (y - x - z)q = z$ through the circle $z = 1$, $x^2 + y^2 = 1$. **[10]**

4. (b) Convert the following to the base indicated against each:

(i) $(266.375)_{10}$ to base 8

(ii) $(341.24)_5$ to base 10

(iii) $(43.3125)_{10}$ to base 2

(iv) Draw the circuit diagram for

$\overline{F} = A\overline{B}C + \overline{C}B$

using NAND to NAND logic long. **[12]**

4. (c) For given equidistant values u_{-1}, u_0, u_1 and u_2, a value is interpolated by Lagrange's formula. Show that it may be written in the form

$$u_x = yu_0 + xu_1 + \frac{y(y^2-1)}{3!}\Delta^2 u_{-1} + \frac{x(x^2-1)}{3!}\Delta^2 u_0,$$

where $x + y = 1$. **[13]**

4. (d) If the fluid fills the region of space on the positive side of x-axis, is a rigid boundary, and if there be a source + m at the point (0, a), and an equal sink at (0, b), and if the pressure on the negative side of the boundary be the same as the pressure of the fluid at infinity, show that the resultant pressure on the boundary is $\pi\rho m^2 (a - b)^2 / ab (a + b)$, where ρ is the density of the fluid. **[17]**

SECTION – B

5. (a) Use Lagrange's method to solve the equation

$$\begin{vmatrix} x & y & z \\ \alpha & \beta & \gamma \\ \frac{\partial z}{\partial x} & \frac{\partial z}{\partial y} & -1 \end{vmatrix} = 0$$

where z = z (x, y). **[10]**

5. (b) Find a complete integral of $(x^2 + y^2)(p^2 + q^2) = 1$. **[10]**

5. (c) Solve the following system of equations by Gauss-Jordan elimination method :

$x_1 + x_2 + x_3 = 3$

$2x_1 + 3x_2 + x_3 = 6$

$x_1 - x_2 - x_3 = -3$ **[10]**

5. (d) Use Hamilton's equations to find the equation of motion of the simple pendulum. **[10]**

5. (e) Show that the velocity potential $\phi = (a/2)\times(x^2 + y^2 - 2z^2)$ satisfies the Laplace equation. Also determine the streamlines. **[10]**

6. (a) Obtain the partial differential equation governing the equations
$\phi(u, v) = 0$, $u = xyz$,
$v = x + y + z$. **[06]**

6. (b) Solve $(D^2 - DD' - 2D)z = \sin(3x + 4y) - e^{2x+y} + x^2y$. **[13]**

6. (c) Reduce $r + 2xs + x^2 t = 0$ to canonical form **[13]**

6. (d) A string of length l is initially at rest in its equilibrium position and motion is started by giving each of its points a velocity v given by $v = kx$ if $0 \le x \le l/2$ and $v = k(l - x)$ if $l/2 \le x \le l$. Find the displacement function $y(x, t)$. **[18]**

7. (a) (i) Draw a logic circuit to realize the function $Y = A.B.C + \overline{A}.\overline{B}.\overline{C} + B$.

(ii) Simplify the expression and draw a logic for the simplified expression. **[10]**

7. (b) A The velocity v of a particle at distance s from a point on its path is given by the table:

s ft	:	0	10	20	30	40	50	60
v ft/sec	:	47	58	64	65	61	52	38

Estimate the time taken to travel 60ft by using Simpson's 1/3 rule. Compare the result with Simpson's 3/8 rule. **[13]**

7. (c) Using modified Euler's method, obtain the solution of the differential equation $\frac{dy}{dt} = t + \sqrt{y} = f(t,y)$ with the initial condition $y_0 = 1$ at $t_0 = 0$ for the range $0 \le t \le 0.6$ in steps of 0.2. **[12]**

7. (d) Write an algorithm in the form of a flow chart for Newton-Raphson method. Describe the cases of failure of this method. **[15]**

8. (a) A sphere of radius a and mass M rolls down a rough plane inclined at an angle α to the horizontal.

If x be the distance of the point of contact of the sphere from a fixed point on the plane, find the acceleration by using Hamilton's equation. **[16]**

8. (b) A uniform rod OA, of length 2a, free to turn about its end O, revolves with uniform angular velocity ω about the vertical OZ through O, and is inclined at a constant angle α to OZ, find the value of α. **[16]**

8. (c) If n rectilinear vortices of the same strength k are symmetrically arranged along generators of a circular cylinder of radius a in an infinite liquid, prove that the vortices will move round the cylinder uniformly in time $\frac{8\pi^2 a^2}{(n-1)k}$, and find the velocity at any point of the liquid. **[18]**

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