Date : .....

A CONSOLIDATED QUESTION PAPER-CUM-ANSWER BOOKLET

IMS™
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MAINS TEST SERIES-2019

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

Under the guidance *of* K. Venkanna

MATHEMATICS

PAPER - I : ODE, STATICS & DYNAMICS AND VECTOR ANALYSIS

TEST CODE: TEST-3: IAS(M)/23-JUNE.-2019

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

INSTRUCTIONS

1. This question paper-cum-answer booklet has 46 pages and has **32 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.

Test Centre

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)			
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3	(a)			
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4	(a)			
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7	(a)			
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8	(a)			
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	(d)			
Total Marks				

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SECTION – A

1. (a) Solve $(x^2 + y^2)(1 + p)^2 - 2(x + y)(1 + p)(x + yp) + (x + yp)^2 = 0$ **[10]**

1. (b) (i) If $L^{-1}\left\{\frac{e^{-1/p}}{p^{1/2}}\right\}=\frac{\cos 2\sqrt{t}}{\sqrt{(\pi t)}}$, find $L^{-1}\left\{\frac{e^{-a/p}}{p^{1/2}}\right\}$ where a > 0.

(ii) Find $L^{-1}\left\{\log\left(1+\frac{1}{p^2}\right)\right\}$. **[10]**

1. (c) Four uniform rods are freely jointed at their extremities and form a parallelogram ABCD, which is suspended by the joint A, and is kept in shape by a string AC. Prove that the tension of the string is equal to half the weight of all the four rods. **[10]**

1. (d) A body moving in a straight line OAB with S.H.M. has zero velocity when at the points A and B whose distances from O are a and b respectively, and has velocity v when half way between them. show that the complete period is $\pi (b - a)/v$. **[10]**

1. (e) If $\nabla^2 f(r) = 0$, show that $f(r) = c_1 \log r + c_2$

where $r^2 = x^2 + y^2$ and c_1, c_2 are arbitrary constants. **[10]**

2. (a) Use the method of variation of parameters to find the general solution of $x^2y'' - 4xy' + 6y = -x^4 \sin x$. **[15]**

2. (b) A heavy chain, of length $2l$, has one end tied at A and the other is attached to a small heavy ring which can slide on a rough horizontal rod which passes through A. If the weight of the ring be n times the weight of the chain, show that its greatest possible distance from A is $\frac{2l}{\lambda}\log\left\{\lambda+\sqrt{\left(1+\lambda^2\right)}\right\}$, $1/\lambda = \mu(2n+1)$ and μ is the coefficient of friction. **[15]**

2. (c) Show that for the curve
$x = a(3u - u^3)$, $y = 3au^2$, $z = a(3u + u^3)$
$$\kappa = \tau = \frac{1}{3a(1+u^2)^2}.$$ **[13]**

2. (d) Find the angle between the surfaces $x^2 + y^2 + z^2 = 9$, and $z = x^2 + y^2 - 3$ at the point $(2, -1, 2)$. **[07]**

3. (a) Solve $x^2(d^3y/dx^3) + 2x(d^2y/dx^2) + 2(y/x) = 10\left(1+\frac{1}{x^2}\right)$. **[10]**

3. (b) A body whose temperature is initially 100°C is allowed to cool in air, whose temperature remains at a constant temperature 20°C. It is given that after 10 minutes, the body has cooled to 40°C. Find the temperature of the body after half an hour. **[10]**

3. (c) A light elastic string of natural length l is hung by one end and to the other end are tied successively particles of masses m_1 and m_2. If t_1 and t_2 be the periods and c_1, c_2 the statical extensions corresponding to these two weights, prove that $g\left(t_1^2 - t_2^2\right) = 4\pi^2\left(c_1 - c_2\right)$. **[17]**

3. (d) Verify Stoke's theorem for $\mathbf{F} = -y^3\,\mathbf{i} + x^3\,\mathbf{j}$, where S is the circular disc $x^2 + y^2 \leq 1$, $z = 0$. **[13]**

4. (a) By using Laplace transform method, Solve $(D^2 + m^2)\, y = a \cos nt$, $t > 0$, if $y = 0$, $Dy = 0$ when $t = 0$. **[15]**

4. (b) A particle slides down the arc of a smooth cycloid whose axis is vertical and vertex lowest, starting at rest from the cusp. Prove that the time occupied in falling down the first half of the vertical height is equal to the time of falling down the second half. **[20]**

4. (c) Let S be the spherical cap $x^2 + y^2 + z^2 = 2a^2$, $z \geq a$, together with its base $x^2 + y^2 \leq a^2$, $z = a$. find the flux of $\mathbf{F} = xz\mathbf{i} - yz\mathbf{j} + y^2\mathbf{k}$ outward through S (i) by evaluating $\iint_S \mathbf{F} \cdot \mathbf{n}$ do directly, (ii) by applying the divergence theorem. **[15]**

SECTION – B

5. (a) Solve $(D-1)^2 (D^2+1)^2 y = \sin^2 (x/2) + e^x + x$. **[10]**

5. (b) Find the orthogonal trajectories of cardioids $r = a(1 - \cos\theta)$, a being parameter. **[10]**

5. (c) A particle is thrown over a triangle from one end of a horizontal base and grazing over the vertex falls on the other end of the base. If A, B be the base angles of the triangle and α the the angle of projection, prove that

$\tan \alpha = \tan A + \tan B$. **[10]**

5. (d) Find the value of $\mathbf{r}$ satisfying the equation

$$\frac{d^2\mathbf{r}}{dt^2} = 6t\mathbf{i} - 24t^2\mathbf{j} + 4\sin t\mathbf{k},$$

given that $\mathbf{r} = 2\mathbf{i} + \mathbf{j}$ and $\frac{d\mathbf{r}}{dt} = -\mathbf{i} - 3\mathbf{k}$ at $t = 0$. **[10]**

5. (e) (i) If $\mathbf{u}$ = $(1/r)$ $\mathbf{r}$, show that $\nabla \times \mathbf{u} = 0$.

(ii) If $\mathbf{u} = \left(\frac{1}{r}\right)\mathbf{r}$ find grad (div $\mathbf{u}$) **[10]**

6. (a) (i) Solve $(2xy^4 e^y + 2xy^3 + y)\,dx + (x^2y^4 e^y - x^2 y^2 - 3x)\,dy = 0$

(ii) Solve $(1 + y^2)\,dx + (x - e^{-\tan^{-1} y})\,dy = 0$, $y(1) = 0$ **[14]**

6. (b) Find the general and singular solution of $y^2 (y - xp) = x^4p^2$. **[10]**

6. (c) Reduce the equation $x^2y'' - 2x(1 + x)y' + 2(1 + x)y = x^3$, $(x > 0)$ into the normal form and hence solve it. **[16]**

6. (d) Prove that $L\left\{\frac{\sin t}{t}\right\} = \tan^{-1}\frac{1}{p}$ and hence find $L\left\{\frac{\sin at}{t}\right\}$. Does the Laplace transform of $\frac{\cos at}{t}$ exist ? **[10]**

7. (a) A body, consisting of a cone and a hemisphere on the same base, rests on a rough horizontal table the hemisphere being in contact with the table show that the greatest height of the cone so that the equilibrium may be stable, is $\sqrt{3}$ times the radius of the hemisphere. **[16]**

7. (b) One end of a uniform rod AB, of length 2a and weight W, is attached by a frictionless joint to a smooth vertical wall, and the other end B is smoothly jointed to an equal rod BC. The middle points of the rods are jointed by an elastic string, of natural length a and modulus of elasticity 4W. Prove that the system can rest in equilibrium in a vertical plane with C in contact with the wall below A, and the angle between the rods is $2 \sin^{-1} (3/4)$. **[16]**

7. (c) A particle moves under a force
$m\mu \{3au^4 - 2(a^2 - b^2)u^5\}$, $a > b$
and is projected from an apse at a distance $(a + b)$ with velocity $\sqrt{\mu/(a+b)}$. Show that the equation of its path is $r = a + b\cos\theta$. **[18]**

8. (a) If **R** be a unit vector in the direction of **r**, prove that

$$\mathbf{R}\times\frac{d\mathbf{R}}{dt}=\frac{1}{r^2}\mathbf{r}\times\frac{d\mathbf{r}}{dt},$$ where $r = |\mathbf{r}|$. **[07]**

8. (b) If **V** (x, y, z) is a v ector function invariant under a rotation of axes, then prove that curl **V** is a vector invariant under this rotation. **[15]**

8. (c) Let $\rho = (x^2 + y^2 + z^2)^{1/2}$. Show that

$$\nabla(\rho^n) = n\rho^{n-2}\mathbf{R},$$

where $\mathbf{R} = \mathbf{i}x + \mathbf{j}y + \mathbf{k}z$. Is there a value of n for which $\mathbf{F} = \nabla(\rho^n)$ represents the "inverse-square law" field? If so, what is this value of n? **[13]**

8. (d) If $\mathbf{F} = (y^2 + z^2 - x^2)\,\mathbf{i} + (z^2 + x^2 - y^2)\,\mathbf{j} + (x^2 + y^2 - z^2)\,\mathbf{k}$, evaluate $\iint \text{curl}\,\mathbf{F} \cdot \mathbf{n}\, dS$ taken over the portion of the surface $x^2 + y^2 + z^2 - 2ax + az = 0$ above the plane $z = 0$, and verify Stoke's theorem. **[15]**

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AIR-04
IFoS-2014


TESWANG GYALTSON
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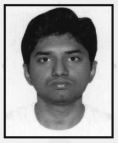
DESHAL DAN
AIR-05
IFoS-2017


PARTH JAISWAL
AIR-05
IFoS-2014


HIMANSHU GUPTA
AIR-05
IFoS-2011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IFoS-2012


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HARSHVARDHAN
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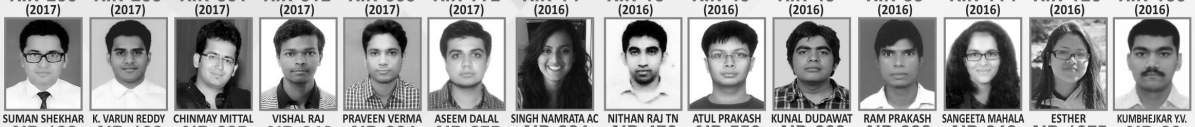

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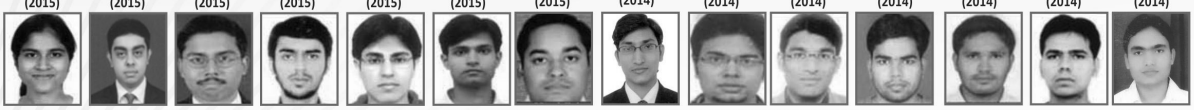

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