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Best Coaching for UPSC MATHEMATICS

CheckList for UPSC MATHEMATICS

1) This Checklist will act as a GUIDE for UPSC MATHEMATICS Preparation, to study the MOST Important Topics as Top Priority.

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Linear Algebra:

S.No	Topic	Tick
1	Given Linear Transformation, Find a) Rank, b) Nullity c) Range Space d) Null Space	
2	Given Matrix Form of Linear Transformation, Find a) Rank, b) Nullity c) Range Space d) Null Space	
3	Given Linear Transformation with Two Different Bases Sets, Find Matrix	
4	Given Linear Transformation with Standard Basis. Find Matrix relative to New Basis Set	
5	State and Prove Cayley Hamilton theorem	
6	Given Homogeneous Equation, Find Dimension and Basis	
7	Find Rank of Matrices	
8	Given Matrix, Find Inverse and Express High order Matrix Polynomial in terms of A	
9	Given Matrices, find Eigen Values and eigen Vectors	
10	Given Matrix A, Find A(power of 300) using Cayley Hamilton	
11	Find Inverse using ONLY ELEMENTART ROW OPERATION	
12	Given Linear Eqn , Find Condition for a) No Solution b) Unique Solution c) Infinite Solutions	
13	Given Matrix A , Find NonSingular Matrix P , such that P(inverse)*A*P is a diagonal matrix	

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14	Given Hermitian Matrix A , Find NonSingular Matrix P , such that P(transpose)*A*P is a diagonal matrix	
15	Given Vector Set: Check for Linear Independency (In Real Field and Complex Field)	
16	Prove DIM (A + B) = DIM A + DIM B.....	
17	Problems using DIM(A +B) relation	
18	State and Prove Rank Nullity Theorem	
19	Reduction to Quadratic Form, Find Index, Signature, Rank	
20	Reduce the quadratic form $7x^2+6y^2+5z^2-4xy-4yz$ to the canonical form	
21	Problems on Unitary, Hermitian given in Krishna Series-Matrices	
22	Show A.(adj A) = |A|* I Show adj (adj A) = A { power of (n-2) square }	
23	Theorems 1) Similar Matrix have same Eigen Values 2) Distinct NonZero Eigen Vectors are Linear Independent 3) Eigen values of A * (Adj A) is Real and show Trace (A* Adj A) = Trace (Adj A * A) 5) Characteristic Root of Adj A	

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CALCULUS and REAL ANALYSIS

S.NO	Topic	Tick
1	**Improper Integrals** Limit Test Cauchy Test Absolute Convergence and conditional convergence Abel Test Dirichlet Test	
2	**Mean Value theorem** Rolle Theorem Lagrange Theorem (Also proof) Cauchy MVT Function Increasing/Decreasing Generalized MVT	
3	**Lagrange Multiplier** Max/Min	
4	**Riemann Integrals** Summation of Series Theorems : 1) Continuous is integrable 2) Bounded and Finite Set of Discontinuity is integrable 3) Bounded and Discontinuity point has fixed limit point is integrable 4) Monotonic is integrable Integral Inequality Eqn First Mean Value Theorem Generalised Mean Value Theorem Second Mean Value Theorem	
5	**Multiple Integrals** Change of Order of Integration Evaluation of Integrals	

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6	**Indeterminants**	
7	**Asymptote** General Method Inspection method Intersection of Curve and Asymptote	
8	**Limits**	
9	**Continuity** Types of Discontinuity Heine Continuity method Bolzano Intermediate Value Theorem Uniform Continuity	
10	**Differentiability**	
11	**Max/ Min Single Variable** Find Max/Min of function Problems to find Max/Min Area, Surface, Height	
12	**Max Min TWO Variables** Find Max/Min of function	
13	**Max/Min Multiple Variables**	
14	**Length of Arc**	
15	**Areas** Cartesian Polar Loop/Asymptotes	
16	**Volumes** Cartesion Polar Spherical System	
17	**Surfaces**	
18	**Partial Differentiation**	
19	**PD Eulers**	
20	**Total Differentiation**	
21	**Definite Integral as Sum**	
22	**Beta Gamma**	

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	Properties Relation between Beta and Gamma Legendre Duplication Formula and Properties	
23	**Beta Gamma Several Variables** Evaluation of Integrals	
24	**Jacobians** Polar Coordinates Root equation problems Connected Equations	
25	**Differentiation under Integral**	
26	**Sequence** Bolzano-Weistress Theorem Cauchy First Theorem on Limit Cauchy second Theorem on Limit Caseros Theorem Cauchy sequence Monotone Convergence Theorem	
27	**Series** Necessary Condition Comparison Test Comparison Test of Second Kind D Alembert Ratio Test Cauchy nTH Root Test Raabe Test Logarithmic Test DE Morgan and Bertrand Test Second Logarithmic Ratio Test Kummer Test Gauss Test Cauchy Integral Test Cauchy Condensation Test	
28	**Uniform Convergence** Cauchy Principle Mn Test	

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	Weirstrass Test Abel Test Dirichlet Test Properties on a)Sum b) Differntiability c) Integrability	
29	**Functions of Several Variables** Limit Continuity Differentiability	
30	**MVT Taylor Maclurin Expansion**	

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NUMERICAL ANALYSIS

S.No	Topic	Tick
1	Obtain (a)Quadrature Formula, (b)Trapezoid Rule, (c)Simpson 1/3, (d) Simpson3/8. Rule and also (e)derive their **Error Formula for ALL RULES**.	
2	Derive Newton Raphson Method, b) Find Condition for its convergence c) Show rate of convergence is quadratic d) Explain its merits and demerits.	
3	Bisection Method	
4	Regula Falsi Method	
5	Secant Method	
6	Iteration Method and its Convergence	
7	Derive Newton Gregory Forward interpolation formula, and its Error.	
8	Derive Newton Gregory's Backward Interpolation formula and its Error	
9	Derive Lagrange interpolation formula and derive its Error formula	

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10	Prove that Lagrange's formula can be put in the form of $$P_n(x) = \sum_{r=1}^{n} \frac{\emptyset(x) f(x_r)}{(x - x_r)\emptyset'(x_r)}$$ *where* $\emptyset(x) = \prod_{r=0}^{n}(x - x_r)$.	
11	Show that the sum of Lagrangian coefficient is unity.	
12	Use Lagrange's interpolation formula to express the function **a)** $\frac{x^2+x-3}{x^3-2x^2-x+2}$ **b)** $\frac{x^2+6x+1}{(x-1)(x+1)(x-4)(x-6)}$ as sums of partial fractions.	
13	Find the parabola passing through points (0,1) (1,3) and (3,55) using Lagrange's formula.	
14	Derive Gauss Quadrature Formula.	
15	Evaluate the integral $I = \int_5^{12} \frac{dx}{x}$. using Gauss Quadrature n=5. Find the value of the integral $\int_0^1 x\, dx$. using Gauss Quadrature n=4.	
16	Solve ODE Problems a) Euler b) Euler Modified c)Runge Kutta Order 1, Order 4	
17	Solve Linear Eqns a) Gauss Elimination b) Gauss Jordan c) Gauss Seidel d) Gauss Jacobi	
18	Use Gauss Jordan to Find Inverse	
19	Conversion a) Decimal to Octogonal and Vice versa	

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	b) Decimal to Hexadeceimal and vice versa	
20	Solve Boolean Expression	

ALGORITHMS and FLOW CHART

	Write Flow Chart and Algorithm for	
1	Lagrange Interpolation	
2	Trapezoid	
3	Simpson 1/3	
4	Simpson 3/8	
5	Regula falsi	
6	Newton Raphson	
7	Fixed point iteration	
8	Euler	
9	RK method	
10	Check for prime number	

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Complex Analysis

S.No	Topic	Tick
1	Given U or V as Harmonic Function, find its Conjugate and also Function	
2	Given Function and Given Point a)Show it satisfy Cauchy Riemann eqn b)Show Analytic or Non-Analytic c)Show Existence of Derivative or Not	
3	Expand in Taylor Series	
4	Expand in Laurent Series	
5	Use Cauchy Residue Theorem, to Evaluate the Integral	
6	Contour Integrations	
7	Application of Rouchi Theorem Given Polynomial Equation, and to show the roots lies in the interval Find Residue of a Given Function at a given Point	
9	Find the Kind of Singularity	
10	Find Region of Convergence of Complex Series (Asked in Previous Year BUT Less Probability of Asking Now)	

Important Theorems of Complex Analysis:

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a) Prove that every power series representing an analytic function inside its circle of convergence

b) If all zeroes of the polynomial $P(z)$ lies in a half plane show that zeros of the derivative $P'(z)$ also lie in the same plane.

c) Suppose that *f* and *g* are two analytic function on the set of ∅ for all complex numbers with $f(1/n)=g(1/n)\ for\ n=1,2,3\ldots$ then show that $f(z)=g(z)$ for each *z* in ∅.

d) Poisson's Integral Formula for A Circle.

If $f(z)$ is analytic in the region $|z| \leq P\ and\ R$ is any number such that 0<R<P then prove that

$$f\left(re^{i\theta}\right) = \frac{1}{2\pi}\int_0^{2\pi} \frac{(R^2 - r^2)f\left(Re^{i\theta}\right)}{R^2 - 2Rrcos(\theta - \emptyset) + r^2} d\emptyset$$

$where\ z = re^{i\theta}$ is any point of the domain $|z| < p$.

e) **(Fundamental theorem of Algebra)**

Let $P(z) = a_0 + a_1z + \ldots.+a_nz^n$, where $n \geq 1$ and $a_n \neq 0$ so that P(z) is a polynomial of degree one or greater. Then the equation P(z) =0 has at least one root.

f) Every polynomial equation $P(z) = a_0+a_1z+a_2z^2+\ldots a_nz^n = 0$, where $n \geq 1$, $a_n \neq 0\ has\ exactly\ n\ roots.$

g) If f(z) has a pole of order m at z_0, then the function ϕ defined by $\phi(z) = (z-z_0)^m f(z)$ has a removable singularity at z_0 and $\phi(z_0) \neq 0$. Also show that the residue at z_0 is given by $\frac{\varphi^{m-1}(z_0)}{(m-1)!}$.

h) Show that a function which has no singularity in the finite part of the plane and has a pole of order n at infinity is a polynomial of degree n.

(i) A polynomial of degree n has no singularities in the finite part of the plane but has a pole of order n at infinity.

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(j) If a function f(z) is analytic for all finite values of z and as |z| → ∞, | $f(z)$ |= a | z |^k then f(z) is a polynomial of degree ≤ k.

(k) If f(z) is a function such that for some positive integer m, a value $\phi(z_0)$ exists with $\phi(z_0) \neq 0$ such that the function $\phi(z) = (z-z_0)^m f(z)$ is analytic at z_0. Then f(z) has a pole of order m at z_0.

Linear Programming

S.No	Topic	Tick
1	Formulation of LPP	
2	Graphical Method of Solution	
3	Simplex Method	
4	Big M Method	
5	Construct Dual and Solve	
6	Transportation Problem	
7	Assignment Problem	

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PDE

S.No	Topic	Tick
1	Formation of PDE of a given function	
2	Formation of PDE of type F [g(x,y,z) , h(x.y,z)] =0	
3	Lagrange Eqns : Various Methods	
4	Surface Orthogonal to a given Surface	
5	Charpit method	
6	Clairaut equations	
7	Jacobi method	
8	Homogeneous Linear PDE with Constant Coefficient	
9	Cauchy Method of Characteristic Strip (Total 10 Qns)	
10	Canonical Form	
11	Linear PDE of Second Order with Constant Coefficient	
	Application of PDE	
12	**Wave Eqn** a) Initial Velocity is zero, Initial Displacement is Given b) Initial Velocity is Given, Initial Displacement is Zero	
13	**Heat Eqn** a)Initial Temperature f(x) .Both Ends suddenly changed to Zero Temperature b)Initial Tempearature (T1 , T2) , suddenly change to (T3 , T4) c)Initial Temperature f(x) .Both Ends Insulated suddenly	

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	d)At t=0 distribution is f(x). Suddenly One end is kept at T1 and other end Insullated	
14	**Laplace Eqns** a)Three sides Temerature is 0, Other side f(x) b)Two sides Temperature is 0, One side f(x), Other side at Infinte Long c)One side Insulated (X-Axis) d)One Side Insulated (Opposite side of X-Axis) e)Two sides Insulated , X-axis side f(x), Other side 0 f)Two sides Insulated, X-axis side 0, Other side f(x) g)Three sides Insulated	
15	**Laplace in Polar Coordinate Sysytem** a)SemiCircular Plate b)Circular Arc c)Circular Plate d)Circular Annulus	

MECHANICS

S.No	Topic	Tick
1	Moment of Inertia	
2	D Alembert Principle Problems	
3	Lagrange Eqns	
4	Hamilton Eqns	
5	Fixed Axis Motions	
6	Motion in 2Dimension	

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FLUID DYANAMICS

S.No	Topic	Tick
1	Lagrangian, Euler methods	
2	Velocity, acceleration in ALL COORDINATE SYSTEM	
3	Eqn of continuity	
4	Boundary conditions	
5	Steam line	
6	Velocity potential	
7	Euler eqn of motion	
8	Bernauli eqn	
9	2D Source and Sink, doublets, Problems on Images	
10	Irrotational motion	
11	Cylinder Motion	
12	Coaxial Cylinder Questions	
13	Spherical motion	
14	Stoke Steam function	
15	Vortex motion	
16	Navier Stoke Eqn	
17	Plane poiseulli flow	
18	Laminar steady flow Coaxial cylinder	

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Analytic Geometry

S.No	Topic	Tick
	Straight Lines	
1	Find coordinate the foot of perpendicular from given point to a plane. And also find distance	
2	Plane and St line: Parallel/ Perpendicular / Coincide	
3	Projection of Line on Plane	
4	Condition for Coplanar Lines	
5	Determine Eqn of St Line intersecting two given Lines	
6	Find Perpendicular distance of a point from line and its foot coordinate	
7	Intersection of 3 Planes	
	Shortest Distance	
1	Find SD between two lines and obtain eqn of SD (Very Imp) Projection Method Two Lines in Symmetric Form One-line General, Other Symmetric Form Two lines in General Form	
1	**Skew Lines** Find locus of line, which intersects set of lines or function	
	Planes	
1	Eqn of plan through 3 points	
2	Angle between planes	
3	Variable Plane Problems	

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4	Bisecting Planes	
5	Combined Eqn of Planes	
6	Projection of planes	
	Spheres	
1	Sphere touching plane	
2	Sphere through Circle	
3	Eqn of tangent plane to sphere and its condition	
4	Polar plane eqn and find pole	
5	Intersection of Spheres and orthogonality condition	
	Cylinder	
1	Eqn parallel to line and guiding curve	
2	Right Circular Cylinder	
3	Tangent Plane	
4	Enveloping Cylinder	
	Cone	
1	Find eqn of cone with Vertex origin cone	
2	Find cone, with non origin vertex	
3	Condition for second degree to represent cone and find coordinates	
4	Tangent Line and Tangent Plane of Cone Condition for Tangency	
5	Reciprocal cone	
6	Angle between lines in which plane cuts Cone	
7	Condition for 3 mutually perpendicular generators	
8	Condition for 3 mutually perpendicular tangent planes	
9	Right Circular Cone	

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10	Enveloping Cone	
	Central Conicoids	
1	Find Eqn of Tangent plane Condition for Tangency	
2	Director Sphere	
3	Polar Planes, Pole	
4	Locus of Chord Bisected at a given point	
5	Normal to Conicoids	
6	Prove 6 normals to ellipsoid	
7	Find cubic curve through feet of normal	
8	Diametral Plane	
9	Problems on Semi conjugate diameter properties	

STATICS and DYNAMICS

S.No	Topic	Tick
1	Rectilinear Motion	
2	SHM	
3	Constrained Motion	
4	Projectile Motion	
5	Problems on Central Forces	
6	Motion in a Plane	
7	Work, Energy,Impulse	
8	Stable and Unstable Equilibrium	
9	Common Catenary	

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10	Virtual Work	
11	Friction	

MODERN ALGBERA

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VECTOR ANALYSIS

S.No	Topic	Tick
1	Directional Derivative : Max/Min , Angle made,	
2	Vector Identities: Proof a) Curl (A XB) b) Div (A X B) c) Grad (A.B) d) Curl(curl A)	
3	Invariance under Transformation	
4	Green Theorem	
5	Stoke Theorem	
6	Divergence Theorem	
7	Work done	
8	Curves in Space	
9	Problems on finding Radius of Curvature, Torsion	
10	Find Curvature Vector	
11	Derive Serret Frennet formula	
12	Show curve lie in Plane	

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ODE

S.No	Topic	Tick
1	Formation of DE	
2	Eqn of 1st Order, 1st Degree Linear Differential Eqns Eqn reducible to Linear form Bernauli Eqn	
3	List of Important Results like Subnornal,subtangent, length of normal and tangent, Eqn of Tangent and Normal Tangent and Normal X and Y intercept Polar subtangent, subnormal, length of tangent, normal	
4	Orthogonal Tarajectory/Oblique Trajectory Eqn	
5	Eqn of First Order but not of first degree Solvable for p Solvable for x Solvable for y Lagrange form Eqn in Claurait Form Eqn reducible to Caurait form Singular Soln	
6	Linear Differential Eqns with Consatnt Coefficients	
7	Homogeneous Linear Eqn/Cauchy Euler Eqn Legendre linear eqns	
8	Method of variation of parameters	
9	Linear Eqn of Second Order Reduction with One known integral Reduction to Normal Changing independent variable	
10	Laplace	
11	Inverse Laplace	
12	Application to initial value problems for 2nd order linear equations with constant coefficients.	

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