Lovely Professional University, Punjab

Course Code	Course Title	Course Planner
MTH166	DIFFERENTIAL EQUATIONS AND VECTOR CALCULUS	11033::Dr. Kulwinder Singh

Course Outcomes :Through this course students should be able to

CO1 :: Define and distinguished between different types of differential equations.

CO2 :: Understand the use of different methods for the solution of differential equations.

CO3 :: Apply the important concepts associated with derivatives of vector fields such as Gradient, divergence, curl, and scalar potential etc.

CO4 :: Analyze the second-order partial differential equations such as the heat, wave and Laplace equation.

CO5 :: Evaluate the line, surface, volume integral using various theorems of vector calculus.

	TextBooks (T)		
Sr No	**Title**	**Author**	**Publisher Name**
T-1	ADVANCED ENGINEERING MATHEMATICS	R.K.JAIN, S.R.K. IYENGER	NAROSA PUBLISHING HOUSE

	Reference Books (R)		
Sr No	**Title**	**Author**	**Publisher Name**
R-1	HIGHER ENGINEERING MATHEMATICS	DR. B.S. GREWAL	KHANNA PUBLISHERS

Relevant Websites (RW)		
Sr No	**(Web address) (only if relevant to the course)**	**Salient Features**
RW-1	http://tutorial.math.lamar.edu/Classes/DE/Exact.aspx	Exact differential equations
RW-2	http://tutorial.math.lamar.edu/Classes/DE/IntroSecondOrder.aspx	Second order linear differential equations
RW-3	http://tutorial.math.lamar.edu/Classes/DE/HOHomogeneousDE.aspx	Homogeneous linear differential equations with constant coefficients
RW-4	http://tutorial.math.lamar.edu/Classes/DE/Wronskian.aspx	Wronskians
RW-5	http://tutorial.math.lamar.edu/Classes/DE/NonhomogeneousDE.aspx	Non homogeneous differential equations
RW-6	http://tutorial.math.lamar.edu/Classes/DE/UndeterminedCoefficients.aspx	Method of undetermined coefficients

RW-7	http://tutorial.math.lamar.edu/Classes/DE/VariationofParameters.aspx	Method of variation of parameters
RW-8	http://tutorial.math.lamar.edu/Classes/DE/SeparationofVariables.aspx	Method of separation of variables
RW-9	http://tutorial.math.lamar.edu/Classes/DE/SolvingHeatEquation.aspx	Solution to heat equation
RW-10	http://tutorial.math.lamar.edu/Classes/DE/TheWaveEquation.aspx	Solution to wave equation
RW-11	http://tutorial.math.lamar.edu/Classes/DE/LaplacesEqn.aspx	Solution to Laplace equation
RW-12	http://tutorial.math.lamar.edu/Classes/CalcIII/VectorFcnsCalculus.aspx	Calculus of vector functions
RW-13	http://tutorial.math.lamar.edu/Classes/CalcIII/GradientVectorTangentPlane.aspx	Gradient of scalar functions
RW-14	http://tutorial.math.lamar.edu/Classes/CalcIII/CurlDivergence.aspx-	Curl and Divergence of vector functions
RW-15	http://tutorial.math.lamar.edu/Classes/CalcIII/LineIntegralsVectorFields.aspx	Line integral of vector field
RW-16	http://tutorial.math.lamar.edu/Classes/CalcIII/GreensTheorem.aspx	Green's Theorem
RW-17	http://tutorial.math.lamar.edu/Classes/CalcIII/SurfIntVectorField.aspx	Surface integral of vector fields
RW-18	http://tutorial.math.lamar.edu/Classes/CalcIII/StokesTheorem.aspx	Stokes's theorem
RW-19	http://tutorial.math.lamar.edu/Classes/CalcIII/DivergenceTheorem.aspx	Gauss's divergence theorem

Audio Visual Aids (AV)		
Sr No	**(AV aids) (only if relevant to the course)**	**Salient Features**
AV-1	https://www.youtube.com/watchv=0Y3cJXmO82Y	Video lecture on Exact differential equations
AV-2	https://www.khanacademy.org/math/differential-equations/first-order-differential-equations/exact-equations/v/exact-equations-example	lecture on Exact differential equations.
AV-3	http://www.nptelvideos.in/2012/11/mathematics-iii.html	Video lectures on Heat, Wave, Laplace equations

LTP week distribution: (LTP Weeks)	
Weeks before MTE	7
Weeks After MTE	7
Spill Over (Lecture)	7

Detailed Plan For Lectures

Week Number	Lecture Number	Broad Topic(Sub Topic)	Chapters/Sections of Text/reference books	Other Readings, Relevant Websites, Audio Visual Aids, software and Virtual Labs	Lecture Description	Learning Outcomes	Pedagogical Tool Demonstration/ Case Study / Images / animation / ppt etc. Planned	Live Examples

An instruction plan is only a tentative plan. The teacher may make some changes in his/her teaching plan. The students are advised to use syllabus for preparation of all examinations. The students are expected to keep themselves updated on the contemporary issues related to the course. Upto 20% of the questions in any examination/Academic tasks can be asked from such issues even if not explicitly mentioned in the instruction plan.

Week 1	Lecture 1	Ordinary differential equations(exact equations)	R-1	RW-1 AV-1	Lecture zero will be delivered to make the students understand the importance of the course that why and how it will be taught. Concept of exact differential equations will be taught to the students.	The students will come to know about the necessary and sufficient conditions for a differential equation to be termed as Exact differential equations and how to solve them.	Lecture cum discussion.	The simplest exact differential equation application is population model in which the rate of growth of the population is directly proportional to the population. A population with this characteristic is modelled by the exact differential equation dp/dt=kp i.e kpdt-dp=0 .There are many things in life that actually do fit this model, and it can be a reasonable short-term model for population growth. However, the thing about exponentials is they grow really, really fast .
	Lecture 2	Ordinary differential equations(equations reducible to exact equations)	R-1	AV-2	The students will be taught the different ways of converting a non-exact equation to exact equation will be taught.	The students will learn about finding I.F. by inspection and finding I.F. for standard forms of non-exact differential equations.	Lecture cum discussion.	

Week 1	Lecture 3	Ordinary differential equations(equations reducible to exact equations)	R-1	AV-2	The students will be taught the different ways of converting a non-exact equation to exact equation will be taught.	The students will learn about finding I.F. by inspection and finding I.F. for standard forms of non-exact differential equations.	Lecture cum discussion.	
Week 2	Lecture 4	Ordinary differential equations(equations of the first order and higher degree)	R-1		The students will be taught to solve the equations which are solvable for p and y.	The students will learn to solve equations of the form f(x,y,p)=0	Lecture cum discussion.	
	Lecture 5	Ordinary differential equations(Clairaut's equation)	R-1		The students will be taught to solve the equations which are solvable for x and Clairaut form of differential equation	The students will learn to solve equations of the form f(x,y,p)=0	Lecture cum discussion	
	Lecture 6	Differential equations of higher order(introduction to linear differential equation, Solution of linear differential equation)	T-1		The concept of homogeneous and non-homogeneous linear differential equations will be taught along with their solutions	The students will learn about the linear differential equations with constant and variable coefficients, intervals on which the equation is normal and the condition under which there exists a unique solution.	Lecture cum discussion.	Second order linear mathematical model can be solved for the solution of problem where a mass weighing 3 lbs. stretches a spring (which is 4 ft. long) 3 inches. If the mass is raised 1 inch above its equilibrium position and given an initial velocity of 2 ft./sec. upward, determine the subsequent motion (i.e. find the distance from the equilibrium position as a function of time). Assume that the air resistance is negligible.

Week 3	Lecture 7	Differential equations of higher order(linear dependence and linear independence of solution)	T-1	RW-4	The students will be taught how the linear combination of functions can be used to decide about their dependence and independence.	The students will learn to utilize the concept of Wronskians to decide about the linear dependence and independence of solutions.	Lecture cum discussion.	Intuitively vectors being linearly independent means they represent independent directions in your vector spaces, while linearly dependent vectors means they don't. So for example if you have a set of vector {x1,...,x5}and you can walk some distance in the x1 direction, then a difference distance in x2, then again in the direction of x3. If in the end you are back where you started, then the vectors are linearly dependent . This is the intuition behind the notion and you can make it into a definition because in the above example if we start at 0 then we walk ai in the xi direction, then the above paragraph says that a1x1+a2x2+a3x3=0. (This is how you should think of linear combinations, as directions to go

								given by your vectors.)
	Lecture 8	Differential equations of higher order(method of solution of linear differential equation- Differential operator)	T-1		The students will be taught the use of differential operator D=d/dx and using it to write the Symbolic form of differential equations.	The students will learn about the prominent use of differential operator which will remain the necessary part for the structure formation for solution of differential equations.	Lecture cum discussion.	
	Lecture 9				Online Assignment			
Week 4	Lecture 10	Differential equations of higher order(solution of second order homogeneous linear differential equation with constant coefficient)	T-1	RW-2	The students will be taught how to form the auxiliary equation using differential operator and then solve this quadratic equation to find form of solution.	The students will learn to write the solution of differential equation when the roots are real and distinct and real and equal and roots are complex .	Lecture cum discussion.	
	Lecture 11	Differential equations of higher order(solution of higher order homogeneous linear differential equations with constant coefficient.)	T-1	RW-3	The students will be taught how to form the auxiliary equation using differential operator and then solve this cubic or biquadratic equation to find form of solution.	The students will learn to write the solution of differential equation when there are multiple real roots and multiple complex roots.	Lecture cum discussion.	
	Lecture 12	Differential equations of higher order(solution of higher order homogeneous linear differential equations with constant coefficient.)	T-1	RW-3	The students will be taught how to form the auxiliary equation using differential operator and then solve this cubic or biquadratic equation to find form of solution.	The students will learn to write the solution of differential equation when there are multiple real roots and multiple complex roots.	Lecture cum discussion.	
Week 5	Lecture 13	Linear differential equation (solution of non-homogeneous linear differential equations with constant coefficients using operator method)	T-1	RW-5	The students will be taught to find Complementary function and Particular Integral for non-homogeneous differential equations and then write down the complete solution.	The students will learn to find particular integral if the function id of the form X=e^ax and X=sin(ax+b) or cos (ax+b) along with case of failure.	Lecture cum discussion.	

Week 5	Lecture 14	Linear differential equation (solution of non-homogeneous linear differential equations with constant coefficients using operator method)	T-1	RW-5	The students will be taught to find Complementary function and Particular Integral for non-homogeneous differential equations and then write down the complete solution.	The students will learn to find particular integral if the function id of the form X=e^ax and X=sin(ax+b) or cos (ax+b) along with case of failure.	Lecture cum discussion.	
	Lecture 15	Linear differential equation (method of variation of parameters)	T-1	RW-7	The students will be taught the general method of solution, called as method of variations of parameters.	The students will learn to use this general method of solution using the concept of non-zero Wronskians for linearly independent solutions.	Lecture cum discussion.	
Week 6	Lecture 16	Linear differential equation (method of undetermined coefficient)	T-1	RW-6	The students will be taught to choose the appropriate form of function using this method of undetermined coefficients.	The students will learn to choose particular integral depending upon the form of function on right hand side of the differential equation.	Lecture cum discussion.	
	Lecture 17				Online Assignment			
	Lecture 18	Linear differential equation (solution of Euler-Cauchy equation)	T-1		The students will be taught this particular form of differential equation and method to solve it.	The students will learn about this differential equation with variable coefficients and how to convert it to equation with constant coefficients and then solve it using the known methods.	Lecture cum discussion.	
Week 7	Lecture 19	Linear differential equation (simultaneous differential equations by operator method)	T-1		The students will be taught to solve Simultaneous differential equations by operator method	The students will learn to solve simultaneous equations by elimination of one of the dependent variable after writing the equations in operator notations.	Lecture cum discussion.	
		SPILL OVER						
Week 7	Lecture 20				Spill Over			

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Week 7	Lecture 21				Spill Over			
		MID-TERM						
Week 8	Lecture 22	Partial differential equation (introduction to partial differential equation)	T-1		The students will be taught this concept of partial differential equations, their formulation and classification.	The students will learn how to formulate the partial differential equations by elimination of arbitrary constants and functions and classification of partial differential equations.	Lecture cum discussion.	
	Lecture 23	Partial differential equation (method of Separation of Variables)	T-1	RW-8	The students will be taught this method of separation of variables to solve pde.	The students will learn how to separate the variables on two sides and then integrate to get the required solution of pde.	Lecture cum discussion.	
	Lecture 24	Partial differential equation (solution of wave equation)	T-1	RW-9	The students will be taught the standard solution of one dimensional wave equation and its related boundary value problems	The students will learn to solve boundary value problems related to one dimensional wave equation.	Lecture cum discussion.	
Week 9	Lecture 25	Partial differential equation (solution of heat equation)	T-1	RW-10	The students will be taught the standard solution of one dimensional heat equation and its related boundary value problems	The students will learn to find the temperature distribution of heat flow with in bar.	Lecture cum discussion.	. Imagine a room with a wall that is made of different materials such as wood, metal or bricks arranged in different ways. The room is at room temperature, say 25?C and does not generate any heat (no air conditioner) and it is surrounded by the outside environment which has a temperature of 0?C. The room

								is so tiny relative to the outside environment therefore any heat flow from the room to the outside would not change the temperature outside. However, the temperature inside the room is prone to changes due to the surrounding temperature. How can a person ensure that he can maintain the room temperature for the longest possible time without the use of an air conditioner?
	Lecture 26	Partial differential equation (solution of Laplace equation)	T-1	RW-11 AV-3	The students will be taught the standard solution of one dimensional heat equation and its related boundary value problems	The students will learn to find the steady-state temperature distribution of heat in thin, flat, rectangular plate.	Lecture cum discussion.	
	Lecture 27	Vector calculus I(limit, continuity and differentiability of vector functions)	T-1	RW-12	The students will be taught to apply the concept of limit, continuity and differentiability to vector quantities.	The students will learn how the concepts of calculus can be applied to vector functions to check their limits, continuity and differentiability.	Lecture cum discussion.	

Week 10	Lecture 28	Vector calculus I(limit, continuity and differentiability of vector functions)	T-1	RW-12	The students will be taught to apply the concept of limit, continuity and differentiability to vector quantities.	The students will learn how the concepts of calculus can be applied to vector functions to check their limits, continuity and differentiability.	Lecture cum discussion.	
	Lecture 29	Vector calculus I(length of space curve)	T-1		The students will be taught to calculate the length of a space curve and velocity and acceleration of particles.	The students will learn to find length of a space curve represented in parametric form and to find velocity and acceleration of particles.	Lecture cum discussion.	
		Vector calculus I(motion of a body or particle on a curve)	T-1		The students will be taught to calculate the length of a space curve and velocity and acceleration of particles.	The students will learn to find length of a space curve represented in parametric form and to find velocity and acceleration of particles.	Lecture cum discussion.	
	Lecture 30	Vector calculus I(gradient of a scalar field and directional derivatives)	T-1	RW-13	The students will be taught about the meaning and the geometrical representation of gradient of a scalar field function.	The students will learn about the del operator and how when it is applied on scalar function can be termed as gradient which is a vector normal to the surface.	Lecture cum discussion.	
Week 11	Lecture 31	Vector calculus I(gradient of a scalar field and directional derivatives)	T-1	RW-13	The students will be taught about the meaning and the geometrical representation of gradient of a scalar field function.	The students will learn about the del operator and how when it is applied on scalar function can be termed as gradient which is a vector normal to the surface.	Lecture cum discussion.	
	Lecture 32	Vector calculus I(divergence and curl of vector field)	T-1	RW-14	The students will be taught about divergence and curl of a vector field.	The students will learn about the application of del operator to vector field functions which gives rise to divergence and curl.	Lecture cum discussion.	
	Lecture 33				Online Assignment			

Week 12	Lecture 34	Vector calculus II(line integral)	T-1	RW-15	The students will be taught the concept of line integral of scalar and vector field.	The students will learn how to calculate line integral of scalar and vector field functions and how to calculate work done using this concept.	Lecture cum discussion.	
	Lecture 35	Vector calculus II(Greens' theorem)	T-1	RW-16	The students will be taught about this important theorem that links line and surface integral.	The students will learn how to calculate line integral using Green's theorem by calculating the surface integral.	Lecture cum discussion.	
	Lecture 36	Vector calculus II(surface area and Surface integral)	T-1	RW-17	The students will be taught about the concept of surface integral and surface area.	The students will learn about the concepts of surface area and surface integral and its use in Stokes's and Gauss's theorems.	Lecture cum discussion.	
Week 13	Lecture 37	Vector calculus II(Stokes' theorem)	T-1	RW-18	The students will be taught about Stokes's theorem.	The students will learn about the relationship of surface integral and line integral via curl of vector field by this theorem.	Lecture cum discussion.	
	Lecture 38	Vector calculus II(Stokes' theorem)	T-1	RW-18	The students will be taught about Stokes's theorem.	The students will learn about the relationship of surface integral and line integral via curl of vector field by this theorem.	Lecture cum discussion.	
	Lecture 39	Vector calculus II(Gauss's divergence theorem)	T-1	RW-19	The students will be taught about Gauss's divergence theorem.	The students will learn about the relationship of surface integral and volume integral via divergence of vector field by this theorem.	Lecture cum discussion.	
Week 14	Lecture 40	Vector calculus II(Gauss's divergence theorem)	T-1	RW-19	The students will be taught about Gauss's divergence theorem.	The students will learn about the relationship of surface integral and volume integral via divergence of vector field by this theorem.	Lecture cum discussion.	

		SPILL OVER						
Week 14	Lecture 41				Spill Over			
	Lecture 42				Spill Over			
Week 15	Lecture 43				Spill Over			
	Lecture 44				Spill Over			
	Lecture 45				Spill Over			

Plan for Tutorial: (Please do not use these time slots for syllabus coverage)

Tutorial No.	Lecture Topic	Type of pedagogical tool(s) planned (case analysis,problem solving test,role play,business game etc)
Tutorial1	Exact equations, Equations reducible to exact equations	Problem Solving
Tutorial2	Equations of the first order and higher degree, Clairaut equation	Problem Solving
Tutorial3	Introduction to linear differential equation, Solution of linear differential equation	Problem Solving
Tutorial4	Solution of linear differential equation, Linear dependence and linear independence of solution	Problem Solving
Tutorial5	Method of solution of linear differential equation- Differential operator	Problem Solving
Tutorial6	Solution of second order homogeneous linear differential equation with constant coefficient	Problem Solving
Tutorial7	Solution of non-homogeneous linear differential equations with constant coefficients using operator method, Method of variation of parameters	Problem Solving
After Mid-Term		
Tutorial8	Method of Separation of Variables, Solution of wave equation	Problem Solving
Tutorial9	Solution of Heat equation, Solution of Laplace equation	Problem Solving
Tutorial10	Limit, continuity and differentiability of vector functions	Problem Solving
Tutorial11	Length of space curve, Motion of a body or particle on a curve	Problem Solving
Tutorial12	Gradient of a scalar field and directional derivatives, Divergence and curl of vector field	Problem Solving
Tutorial13	Line integral and Greens' theorem, Surface area and Surface integral	Problem Solving
Tutorial14	Stokes' theorem, Gauss divergence theorem	Problem Solving