Sana'a University
Faculty of Engineering
Mechanical Engineering Department
Mechanical Engineering Program

25. Course Specification of Differential Equations

I. Course Identification and General Information:

1.	Course Title:	Differential Equations.				
2.	Course Code & Number:	BR122.				
3.	Credit Hours:	C.H				TOTAL CR. HRS
		Th.	Seminar/Tu	Pr	Tr.	
		2	2	-	-	3
4.	Study level/ semester at which this course is offered:	Second Year - Second Semester				
5.	Pre –requisite (if any):	Linear Algebra (FR001).				
6.	Co –requisite (if any):	None.				
7.	Program (s) in which the course is offered:	Mechanical Engineering Program.				
8.	Language of teaching the course:	English Language.				
9.	Location of teaching the course:	Mechanical Engineering Department.				
10.	Prepared By:	Asst. Prof. Dr. Adnan Al-Salihi.				
11.	Date of Approval:					

II. Course Description:

This course introduces students to differential equations that will be used for solving mathematical problems that arise in science and engineering. Students will develop the methods to formulate basic engineering problems. In addition, topics to be covered include: Basic concepts, classification and formation of differential equations (ODEs and PDEs), general and particular solutions. Solutions of ordinary differential equations (first order, second order and higher orders) by various methods, geometric and physical applications, Laplace transform; properties and applications; solutions of differential equations using Laplace transform; Introduction to Partial differential equations.

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Asst. Prof. Dr. Adel Ahmed Al-Shakiri	Assoc. Prof. Dr. Mohammad Algorafi	Prof. Dr. Mohammed AL-Bukhaiti	Assoc. Prof. Dr. Huda Al-Emad	Prof. Dr. Al-Qassim Mohammed Abbas

	III. Course Intended learning outcomes (CILOs) of the course	Referenced PILOs
a1	Recognize the definitions, basic properties and theorems of the Laplace Transforms, and differential equations including their solutions and applications.	A1
a2	Identify the most important and appropriate techniques for solving various types of differential equations.	A4
b1	Categorize the differential equations according to their types, order, degree, linearity and homogeneity and suggest the suitable method for solving every kind.	B1
b2	Explore the appropriate mathematical methods for solve a mechanical engineering problem governing by the ordinary and partial differential equations, as well as analyze, interpret the results and predict behavior.	
c1	Apply the theorems and techniques for solving differential equations to solve practical Mechanical engineering problems.	C1
c2	Perform mathematics models and solve problems in engineering applications using Laplace transforms.	
c3	Solve the different types of DEs analytically (e.g. exact, homogeneous, linear, systems of linear DEs and linear higher order, etc.) that describe models occurring in mechanical engineering.	C2
d1	Assess to manage tasks, time, and resources.	D2
d2	Cooperate effectively in-group and individually.	D5

(A) Alignment Course Intended Learning Outcomes of Knowledge and Understanding to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
a1- Recognize the definitions, basic properties and theorems of the Laplace Transforms, and differential equations including their solutions and applications.	- Active Lectures - Tutorials - Interactive Class Discussions and Presentations. - Exercises and Home Works.	- Written Tests - Homework - Presentations
a2- Identify the most important and appropriate techniques for		- Written Tests - Homework

solving various types of differential equations.	- Case Studies and the use of Communication and Information Technology.	- Presentations

(B) Alignment Course Intended Learning Outcomes of Intellectual Skills to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
b1- Categorize the differential equations according to their types, order, degree, and suggest the suitable method for solving every kind.	- Active Lectures - Tutorials - Interactive Class Discussions and Presentations. - Exercises and Home Works. - Case Studies and the use of Communication and Information Technology.	- Written Tests - Homework - Presentations
b2- Explore the appropriate mathematical methods for solve a mechanical engineering problem governing by the ordinary and partial differential equations, as well as analyze, interpret the results and predict behavior.		- Written Tests - Homework - Presentations

© Alignment Course Intended Learning Outcomes of Professional and Practical Skills to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
c1- Apply the theorems and techniques for solving differential equations to solve practical engineering problems.	- Active Lectures - Tutorials - Interactive Class Discussions and Presentations. - Exercises and Home Works. - Case Studies and the use of Communication and	- Written Tests - Homework - Presentations
c2- Perform mathematics models and solve problems in engineering applications using Laplace transforms.		- Written Tests - Homework - Presentations
c3- Solve the different types of DEs analytically (e.g. exact,		- Written Tests - Homework

homogeneous, linear differential higher order, etc.) models occurring in engineering.	linear, systems of equations and linear that describe mechanical	Information Technology. - Team Work (Group Learning)	- Presentations

(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
d1- Assess to manage tasks, time, and resources.	Team Work (Group Learning)	- Presentations, - Reports
d2- Cooperate effectively in group and individually.	Team Work (Group Learning)	- Presentations, - Reports

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IV. Course Content:

A – Theoretical Aspect:

Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	Contact Hours
1	Introduction, Formulation and solutions of differential equations.	a1, b1	- Basic concepts and definitions. - Classification of differential equations, types, order and degree, linearity and homogeneous. -Formulation of Des. -Solution of D.Es -Boundary and initial conditions.	2	4
2	First order ordinary differential equations.	a1, a2, b2, c3,	-Separable equations and equations reducible to Separable. -Exact equations and equations reducible to exact. -Linear equations and equations reducible to linear (Bernoull's and Riccati equation).	2	4
3	Modeling with First-Order Differential Equations.	a1, b2, c1,	-Growth and Decay -Newton's Law of Cooling / Warming -Mixtures -Series Circuits -Population Dynamics -Logistic Equation -Chemical Reactions.	1	2

4	Higher order ODEs.	a1, a2, b1, b2, c3	-Linear independence and linear dependence -Homogenous equations with constant coefficients. -Nonhomogeneous equations with constant coefficients -Operator method. -Undetermined coefficients method. -Method of variations of parameter. -equations with variable coefficients -Cauchy-Euler Equation. -Lagrange Equation. Applications on nth order differential equations.	2	4
5	Mid-Term Exam.	a1, b2, c1, c3, d1	-The First 6 Chapters.	1	2
6	Modeling with Higher-Order Differential Equations.	a1, b2, c1,	-Spring/Mass Systems: Free Undamped Motion -Double Spring Systems -Spring/Mass Systems: Free Damped Motion -Spring/Mass Systems: Driven Motion -Series Circuit Analogue -Deflection of a Beam -Eigenvalues and Eigen functions -Buckling of a Thin Vertical Column -Rotating String	1	2
7	Systems of Differential	a1,b2, c3	-Radioactive Series -Mixtures	1	2

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	Equations and modeling with Systems of First-Order Des.		-A Predator–Prey Model -Competition Models -Networks.		
8	Mid-Term Exam.	a1, b2, c1, c3, d1	-The First 6 Chapters.	1	2
9	Introduction to Laplace Transform (Definitions and Properties).	a1, c2, d1	-Definition of Laplace transforms. -Laplace transform of elementary functions. -Properties and theorem of Laplace transform. -Laplace transform of special functions: unit step function, Dirac-delta function and periodic functions. -Generalization of Laplace Transforms by means of Gamma functions.	2	4
10	Inverse Laplace Transform.	a1, c2, d1	-Basic concepts and definitions. - Properties and theorems of Inverse Laplace transform. -Inverse Laplace transform by partial fraction and convolution theorem.	1	2
11	Solving Initial Value Problems and Linear Systems with Laplace Transforms and Applications.	a1, c1, c2,,d2	-Solving Initial Value Problems and Linear Systems of ODEs with Laplace Transforms -Coupled Springs -Networks	1	2

12	Introduction of Partial Differential Equations.	a1, a2, b1, c2,	-Introduction and classification of PDEs. PDEs in Physics and Engineering (heat, wave and Laplace equations)	1	2
13	Final Exam.	a1, a2, b1, b2, c1, c2, c3, d1	All Chapters.	1	2
Number of Weeks /and Units Per Semester				**16**	**32**

B - Tutorial Aspect:

Order	Tasks/ Experiments	Number of Weeks	Contact Hours	Learning Outcomes
1	Introduction, Formulation and solutions.	2	4	a1, a2, b1, b2, c1, , d1
2	First order ordinary differential equations.	2	4	a1, a2, b1, b2, c1, c2, c3, d1
3	Modeling with First-Order Differential Equations	1	2	a1, a2, b1, c1, c3, d1
4	Higher order ODEs	2	4	a1, a2, b1, b2, c1, c2, c3, d1
5	Modeling with Higher-Order Differential Equations	1	2	a1, a2, b1, b2, c1, c2, c3, d1
6	Systems of Differential Equations and modeling with Systems of First-Order DEs	1	2	a1, b2, c1, c2, c3, d1
7	Introduction to Laplace Transform (Definitions and Properties)	2	4	a1, a2, b1, b2, c1, c2, c3, d1
8	Inverse Laplace Transform	1	2	a1, a2, b1, b2, c1, c2, c3, d1
9	Solving Initial Value Problems and Linear Systems with Laplace Transforms and Applications	1	2	a1, a2, b1, b2, c1, c2, c3, d1
10	Introduction of Partial Differential Equations	1	2	a1, a2, b1, b2, c1, c2, c3, d1
Number of Weeks /and Units Per Semester		**14**	**28**	

V. Teaching strategies of the course:

- Active Lectures
- Tutorials
- Interactive Class Discussions and Presentations.
- Exercises and Home Works.
- Case Studies and the use of Communication and Information Technology.
- Team Work (Group Learning)

VI. Assignments:

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark
1	Assignments on solving first order differential equations.	a1, a2, b1, b2, c1, c3, d1, d2	2	3
2	Assignments on solving higher order differential equations.	a1, a2, b2, c1, c3 d1, d2	4	3
3	Assignments on Modeling with First-Order and higher order differential equations.	a1, a2, b2, c1, c3, d1, d2	6	3
4	Assignments on using Laplace Transform	a1, c2, d1, d2	9	3
5	Assignments on solving PDEs.	a1, a2, b1, c1, c3	11	3
Total				**15**

VII. Schedule of Assessment Tasks for Students During the Semester:

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment	Aligned Course Learning Outcomes
1	Assignments	3, 5, 9, 11	15	10 %	a1, a2, b1, b2, c1, c2, c3,d2
2	Quizzes	2,4,6,8,10	15	10 %	a1, a2, b1, b2, c1, c2, c3,d1
3	Mid-Term Exam	8	30	20 %	a1, a2, b1, b2, c1, c3,d1
4	Final Exam	16	90	60 %	a1, a2, b1, b2, c1, c2, c3,d1

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Total Assessments Mark/Percentage	**150**	**100 %**	

VIII. Learning Resources:

- *Written in the following order: (Author - Year of publication – Title – Edition – Place of publication – Publisher).*

1- Required Textbook(s) (maximum two).

1- Dennis G. Zill, 2017, Advanced Engineering Mathematics, 6th Edition, USA, Jones & Bartlett Learning.
2- Rajesh Pandey, 2010, A Text Book Of Engineering Mathematics, Vol (II), word press, First edition.

2- Essential References.

1- Erwin Kreyszig, 2011, Advanced Engineering Mathematics, 10th Edition, USA, John Wiley & Sons, Inc.
2- Alan Jeffrey, 2002, Advanced Engineering Mathematics, USA, Harcourt/Academic Press.
3- Higher Engineering Mathematics, Fifth Edition by John Bird, Elsevier Ltd. 2006.
4- Frank Ayres, Jr, 1981, Schaum's Outline of Theory and problems of Differential Equations in SI Metric Units, First Edition, McGRAW-HILL BOOKCOMPANY.

3- Electronic Materials and Web Sites *etc*.

1- wolframMathworld
http://mathworld.wolfram.com/topics/CalculusandAnalysis.html

I. Course Policies:

1	**Class Attendance:** - The student should be attending not less than 75% of total contact hours of the subject, otherwise he will not able to take exam and be considerd as an exam failure. If the student is absent due to illness, he/she should bring an approved statement from university Clinic.
2	**Tardy:** - For lateness in attending the class, the student will be initially notified. If he repeates late in attending class he will be considered absent.
3	**Exam Attendance/Punctuality:** - The student should attend the exam on time. He is permitted to attend the exam half one hour from exam beginning, after that he/she will not be permitted to take exam and he/she is considered absent in the exam.

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4	**Assignments & Projects:** - In general one assignment is given after each chapter of a course. The student should submit the assignment on time, mostly one week after giving the assignment
5	**Cheating**: - For cheating in exam, the student is considered as failure. In case the cheating is repeated three times during study the student will be disengaged from the Faculty
6	**Plagiarism**: Plagiarism is the attending of the student the exam of a course instead of other student. If the examination committee proved a plagiarism of a student, he will be disengaged from the Faculty. The final disengagement of the student from the Faculty should be confirmed from the Student Affair Council of the university.
7	**Other policies:** - The mobile phone is not allowable to be used during class lecture. It must be switched off, otherwise the student will be ordered to leave the lecture room. - The mobile phone is not allowed to be taken during the examination time. - Lecture notes and assignments may be given directly to students using soft or hard copy.

Reviewed By	**Vice Dean for Academic Affairs and Post Graduate Studies: Asst. Prof. Dr. Tarek A. Barakat** **President of Quality Assurance Unit: Assoc. Prof. Dr. Mohammed Algorafi** **Name of Reviewer from the Department: Assoc. Prof. Dr.Riyad Muharam**
	Deputy Rector for Academic Affairs Asst. Prof. Dr. Ibrahim AlMutaa **Assoc. Prof. Dr. Ahmed Mujahed** **Asst. Prof. Dr. Munasar Alsubri**

25. Course Plan of Differential equations

I. Information about Faculty Member Responsible for the Course:

		Office Hours					
Name of Faculty Member	Asst. Prof. Dr. Adnan Alsalihi						
Location& Telephone No.	Sana'a university 770499879	**SAT**	**SUN**	**MON**	**TUE**	**WED**	**THU**

Head of Department Asst. Prof. Dr. Adel Ahmed Al-Shakiri	Quality Assurance Unit Assoc. Prof. Dr. Mohammad Algorafi	Dean of the Faculty Prof. Dr. Mohammed AL-Bukhaiti	Academic Development Center & Quality Assurance Assoc. Prof. Dr. Huda Al-Emad	Rector of Sana'a University Prof. Dr. Al-Qassim Mohammed Abbas

E-mail	Adnans2000@gmail.com						

II. Course Identification and General Information:

1.	Course Title:	Differential Equations.				
2.	Course Number & Code:	BR122.				
3.	Credit hours:	C.H				TOTAL CR. HRS
		Th.	Seminar/Tu.	Pr.	Tr.	
		2	2	-	-	3
4.	Study level/year at which this course is offered:	Second Year - Second Semester.				
5.	Pre –requisite (if any):	Linear Algebra (FR001).				
6.	Co –requisite (if any):	None.				
7.	Program (s) in which the course is offered	Mechanical Engineering Program.				
8.	Language of teaching the course:	English Language.				
9.	System of Study:	Semesters.				
10	Mode of delivery:	Lectures and Tutorials.				
11	Location of teaching the course:	Mechanical Engineering Department.				

III. Course Description:

This course introduces the student to differential equations that will be used for solving mathematical problems that arise in science and engineering. Students will develop the methods to formulate basic engineering problems. In addition, topics to be covered include; basic concepts, classification and formation of differential equations (ODEs and PDEs), general and particular solutions, solutions of ordinary differential equations (first order, second order and higher orders) by various methods, geometric and physical applications, Laplace transform; properties and applications; solutions of differential equations using Laplace transform; Introduction to Partial differential equations.

IV. Intended learning outcomes (ILOs) of the course:

1.	Recognize the definitions, basic properties and theorems of the Laplace Transforms, and differential equations including their solutions and applications.

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2.	Identify the most important and appropriate techniques for solving various types of differential equations.
3.	Categorize the differential equations according to their types, order, degree, linearity and homogeneity and suggest the suitable method for solving every kind.
4.	Explore the appropriate mathematical methods for solve a mechanical engineering problem governing by the ordinary and partial differential equations, as well as analyze, interpret the results and predict behavior.
5.	Apply the theorems and techniques for solving differential equations to solve practical Mechanical engineering problems.
6.	Perform mathematics models and solve problems in engineering applications using Laplace transforms.
7.	Solve the different types of DEs analytically (e.g. exact, homogeneous, linear, systems of linear DEs and linear higher order, etc.) that describe models occurring in mechanical engineering.
8.	Assess to manage tasks, time, and resources.
9.	Cooperate effectively in-group and individually.

V. Course Content:

A – Theoretical Aspect:

Order	Units/Topics List	Sub Topics List	Week Due	Contact Hours
1	Introduction, Formulation and solutions of differential equations.	- Basic concepts and definitions. - Classification of differential equations, types, order and degree, linearity and homogeneous. -Formulation of Des. -Solution of D.Es -Boundary and initial conditions.	1st,2nd	4
2	First order ordinary differential equations.	-Separable equations and equations reducible to Separable. -Exact equations and equations reducible to exact.	3rd,4th	4

		-Linear equations and equations reducible to linear (Bernoull's and Riccati equation).		
3	Modeling with First-Order Differential Equations	-Growth and Decay -Newton's Law of Cooling / Warming -Mixtures -Series Circuits -Population Dynamics -Logistic Equation -Chemical Reactions.	5 th	2
4	Higher order ODEs	-Linear independence and linear dependence -Homogenous equations with constant coefficients. -Nonhomogeneous equations with constant coefficients -Operator method. -Undetermined coefficients method. -Method of variations of parameter. -equations with variable coefficients -Cauchy-Euler Equation. -Lagrange Equation. Applications on nth order differential equations.	6 th ,7th	4
5	Mid-Term Exam	-The First Sixth Chapters	8th	2
6	Modeling with Higher-Order Differential Equations	-Spring/Mass Systems: Free Undamped Motion -Double Spring Systems -Spring/Mass Systems: Free Damped Motion -Spring/Mass Systems: Driven Motion -Series Circuit Analogue -Deflection of a Beam -Eigenvalues and Eigenfunctions -Buckling of a Thin Vertical Column	9 th	2

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		-Rotating String		
7	Systems of Differential Equations and modeling with Systems of First-Order Des	-Radioactive Series -Mixtures -A Predator–Prey Model -Competition Models -Networks.	10 th	2
8	Introduction to Laplace Transform (Definitions and Properties)	-Definition of Laplace transforms. -Laplace transform of elementary functions. -Properties and theorem of Laplace transform. -Laplace transform of special functions: unit step function, Dirac-delta function and periodic functions. -Generalization of Laplace Transforms by means of Gamma functions.	11 th, 12 th	4
9	Inverse Laplace Transform	-Basic concepts and definitions. - Properties and theorems of Inverse Laplace transform. -Inverse Laplace transform by partial fraction and convolution theorem.	13 th	2
10	Solving Initial Value Problems and Linear Systems with Laplace Transforms and Applications	-Solving Initial Value Problems and Linear Systems of ODEs with Laplace Transforms -Coupled Springs -Networks	14 th	2
11	Introduction of Partial Differential Equations	-Introduction and classification of PDEs. PDEs in Physics and Engineering (heat, wave and Laplace equations)	15 th	2
12	Final Exam	All Chapters	16 th	2
Number of Weeks /and Units Per Semester			**16**	**32**

B– Tutorial Aspect:

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Order	Topics List	Week Due	Contact Hours
1	Introduction, Formulation and solutions.	1st and 2nd	4
2	First order ordinary differential equations.	3rd and 4th	4
3	Modeling with First-Order Differential Equations	5th	2
4	Higher order ODEs	6th and 7th	4
5	Modeling with Higher-Order Differential Equations	8th	2
6	Systems of Differential Equations and modeling with Systems of First-Order Des	9th	2
7	Introduction to Laplace Transform (Definitions and Properties)	10th &11th	4
8	Inverse Laplace Transform	12th	2
9	Solving Initial Value Problems and Linear Systems with Laplace Transforms and Applications	13th	2
10	Introduction of Partial Differential Equations	14th	2
Number of Weeks /and Units Per Semester		**14**	**28**

VI. Teaching strategies of the course:

- Active Lectures
- Tutorials
- Interactive Class Discussions and Presentations.
- Exercises and Home Works.
- Case Studies and the use of Communication and Information Technology.
- Team Work (Group Learning)

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VII. Assignments:

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark
1	Assignments on solving first order differential equations.	a1, a2, b1, b2, c1, c3, d1, d2	2	3
2	Assignments on solving higher order differential equations.	a1, a2, b2, c1, c3 d1, d2	4	3
3	Assignments on Modeling with First-Order and higher order differential equations.	a1, a2, b2, c1, c3, d1, d2	6	3
4	Assignments on using Laplace Transform	a1, c2, d1, d2	9	3
5	Assignments on solving PDEs.	a1, a2, b1, c1, c3	11	3
	Total			**15**

VIII. Schedule of Assessment Tasks for Students During the Semester:

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment	Aligned Course Learning Outcomes
1	Assignments	3, 5, 9, 11	15	10 %	a1, a2, b1, b2, c1, c2, c3, d2
2	Quizzes	2,4,6,8,10	15	10 %	a1, a2, b1, b2, c1, c2, c3, d1
3	Mid-Term Exam	8	30	20 %	a1, a2, b1, b2, c1, c3, d1
4	Final Exam	16	90	60 %	a1, a2, b1, b2, c1, c2, c3, d1
	Total		**150**	**100%**	

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http://mathworld.wolfram.com/topics/CalculusandAnalysis.html

II. Course Policies:

1	**Class Attendance:** - The student should be attending not less than 75% of total contact hours of the subject, otherwise he will not able to take exam and be considerd as an exam failure. If the student is absent due to illness, he/she should bring an approved statement from university Clinic.
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