

Khulna University
 Science, Engineering and Technology School
 Discipline: **Mathematics**, Program: **B.Sc. (Hons.)**
 Year: **Third**, Term: **II** Examination-2026; Session: **2024-2025**
 Course Code: **0541 12 Math 3201**
 Course Title: **Mathematical Methods**
 Total Marks: **60**, Time: **03** Hours, Credit: **03**



- The figures in the margin indicate full marks. The questions are of equal value.
- Use separate answer script for each section.

Section-A

There are **FOUR** questions in this section. Answer any **THREE** questions

		Marks
1.	(a) Define periodic function and Fourier series. [L1; CLO1]	02
	(b) Describe the period and range of absolute sine and sawtooth wave. [L5; CLO1]	04
	(c) Obtain the Fourier series for even and odd functions. [L3; CLO1]	04
2.	(a) Write down the Dirichlet's conditions and describe Fourier sine and cosine series. [L1; CLO3]	02
	(b) What are the key points of differentiation and integration of Fourier series? [L1; CLO4]	03
	(c) Find the Fourier series expansion of the function $f(x) = x + x^2$ in the interval $-\pi < x < \pi$. Hence deduce that $\sum_{n=1}^{\infty} \frac{1}{n^2} = \frac{\pi^2}{6}$. [L5; CLO3]	05
3.	(a) What is the convergency of Fourier series? [L1; CLO3]	02
	(b) Describe different types of convergency for the Fourier series. [L4; CLO3]	03
	(c) Expand in Fourier series the function $f(x) = x \sin x$ in the interval $-\pi < x < \pi$. Hence deduce that $\frac{\pi}{4} = \frac{1}{2} + \frac{1}{1.3} - \frac{1}{3.5} + \frac{1}{5.7} - \dots$ [L2; CLO3]	05
4.	(a) State Parseval's Formula. [L1; CLO4]	02
	(b) Let $f(x) = x$ on $[-\pi, \pi]$. Use Parseval's formula to evaluate the sum $\sum_{n=1}^{\infty} \frac{1}{n^2}$. [L1; CLO4]	03
	(c) Use finite Fourier transforms to solve the following boundary value problem, $\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2}$; $U(0, t) = 0$, $U(\pi, t) = 0$; $U(x, 0) = 2x$, $0 < x < \pi, t > 0$ by Fourier transform and interpret physically. [L3; CLO4]	05

Section-B

There are **FOUR** questions in this section. Answer any **THREE** questions

5.	(a) Define finite Fourier sine and cosine transform. [L1; CLO5]	02
	(b) Prove that $\int_0^{\infty} \frac{x \sin mx}{x^2 + 1} dx = \frac{\pi}{2} e^{-m}$, $m > 0$. [L5; CLO5]	04
	(c) Find the (a) finite Fourier sine transforms and (b) finite Fourier cosine transforms of the function $F(x) = 2x$, $0 < x < 4$. [L1; CLO5]	04
6.	(a) Define Laplace's transformation with example. [L1; CLO4]	02
	(b) If $\mathcal{L}\{F(t)\} = f(s)$ then show that $\mathcal{L}\left\{\int_0^t F(u) du\right\} = \frac{f(s)}{s}$. [L2; CLO4]	04
	(c) Using Laplace transform, prove that $\int_0^{\infty} e^{-x^2} dx = \frac{\sqrt{\pi}}{2}$. [L5; CLO4]	04
7.	(a) State and proof the first and second shifting property of inverse Laplace's transformation. [L5; CLO7]	04
	(b) Determine the inverse Laplace's transformation of $\frac{s+4}{s(s-1)(s^2+4)}$. [L5; CLO7]	03
	(c) If $\mathcal{L}^{-1}\{f(s)\} = F(t)$, then show that $\mathcal{L}^{-1}\left\{\frac{f(s)}{s}\right\} = \int_0^t F(u) du$. [L4; CLO7]	03
8.	(a) By using the Laplace's transformation technique, solve the initial value problem: $\frac{d^2 y}{dt^2} + 2 \frac{dy}{dt} + 2y = 5 \sin t$, $y(0) = y'(0) = 0$. [L3; CLO8]	04
	(b) Using Laplace transform, solve $\frac{\partial u}{\partial t} = 2 \frac{\partial^2 u}{\partial x^2}$, $U(0, t) = 0$, $U(5, t) = 0$, $U(x, 0) = 10 \sin 4\pi x - 5 \sin 6\pi x$. [L4; CLO8]	06

***** THE END *****

*Levels of Bloom's cognitive domain:

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 Year: **Third**, Term: **II** Examination-2026; Session: **2024-2025**
 Course Code: **0541 12 Math 3207**
 Course Title: **Numerical Analysis**



Total Marks: **60**, Time: **03** Hours, Credit: **03**

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Section-A

There are **FOUR** questions in this section. Answer any **THREE** questions

Marks

1. (a) Show that the 1^{st} difference of a polynomial of degree n is a polynomial of degree $(n-1)$ and the $(n+1)^{th}$ difference of a polynomial of degree n is zero. [L3; CLO1] **05**

- (b) If h is very small, prove that $\Delta^{n+1} f(x_0) \equiv h^{n+1} f^{(n+1)}(x_0)$. [L3; CLO1] **05**

2. (a) Apply Lagrange's formula to evaluate the value of $f(9)$ from the following table; [L5; CLO2] **05**

x	5	7	11	13	17
$f(x)$	150	392	1452	2366	5202

- (b) Derive Newton's general interpolation formula for unequal intervals in standard form. [L3; CLO2] **05**

3. (a) Evaluate the function $f(x)$ by using the following table and also find the value of y when $x = 3$ [L5; CLO2] **05**

x	0	1	2	5
$f(x)$	2	3	12	147

- (b) Using Gauss's backward formula evaluate $\sin(0.197)$ for the following table: [L5; CLO2] **05**

x	0.15	0.17	0.19	0.21	0.23
$\sin x$	0.1494	0.1692	0.1889	0.2085	0.2280

4. (a) Derive the Newton-Raphson method to solve $f(x) = 0$ mathematically as well as geometrically. Also, find the error expression and convergence criteria of the above method. [L3; CLO5] **05**

- (b) Find the root of $f(x) = x \sin x - 1$ by using the modified Newton-Raphson method with $x_0 = 1$. [L3; CLO4] **06**

Section-B

There are **FOUR** questions in this section. Answer any **THREE** questions

5. (a) Find the real root of the equation $x^2 + 2x - 6 = 0$ by Newton-Raphson method, correct up to 6 decimal places. [L2; CLO1] **05**

- (b) Derive Quadrature formula for numerical integration and also derive the Simpson's 1/3 rule for numerical integration. Compute by Simpson's 1/3 rule, the value of the integral **05**

$$\int_0^{\pi/3} \sqrt{\cos \theta} d\theta. \text{ [L3; CLO4]}$$

6. (a) Evaluate $y = \int_0^1 \frac{1}{1+x^2} dx$ using (i) Trapezoidal rule and (ii) Simpson's $\frac{3}{8}$ rule. Also find the error in each case. [L5; CLO4] **05**

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- (b) Solve the system of equation by Gaussian elimination method: [L3; CLO1] 05
- $$2x + y + z = 10$$
- $$3x + 2y + 3z = 18$$
- $$x + 4y + 9z = 16$$
7. (a) Derive Modified Euler's method geometrically to solve an ordinary differential equation 05
- $$\frac{dy}{dx} = f(x, y) \text{ . [L3; CLO3]}$$
- (b) Explain the Jacobi iteration method. Apply the Jacobi iterative method to solve 05
- $$5x - 2y + 3z = -1; -3x + 9y + z = 2; x - y - 7z = 3. \text{ [L1; CLO1]}$$
8. (a) Apply 4th order Runge-Kutta method to find the approximation of y when $x = 1$, given 05
- that $\frac{dy}{dx} = \frac{y-x}{y+x}$ and $y = 1$ when $x = 0, h = 0.2$ [L3; CLO3]
- (b) Linearized the nonlinear system $y = f(x_1, x_2)$ using Taylor series. [L4; CLO3] 05

***** THE END *****

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 Year: **Third**, Term: **II** Examination-2026; Session: **2024-2025**
 Course Code: **0541 12 Math 3203**
 Course Title: **Mechanics**



Total Marks: **60**, Time: **03** Hours, Credit: **03**

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Section-A

There are **FOUR** questions in this section. Answer any **THREE** questions

Marks

- | | | | |
|----|-----|---|----|
| 1. | (a) | Forces P, 2P, 3P act along the sides of a triangle formed by the lines $x = 0, y = 0$ and $3x + 4y = 5$. Find the magnitude of the resultant and the equation of the line of action of the resultant. [L6; CLO1,2] | 03 |
| | (b) | If six forces of relative magnitude 1, 2, 3, 4, 5 and 6 act along the sides of a regular hexagon taken in order, show that the single equivalent force of the relative magnitude 6 and that it acts along a line parallel to the force 5, at a distance from the center of the hexagon $3\frac{1}{2}$ times the distance of a side from the center. [L4; CLO1,2] | 07 |
| 2. | (a) | A heavy uniform rod of length 'b' rest with one end against a smooth vertical wall, the other end being tied to a point of the wall by a string of length l. Prove that the rod may remain in equilibrium at an angle θ to be the wall given by $\cos^2 \theta = (l^2 - b^2)/3b^2$. [L5; CLO3] | 05 |
| | (b) | State and prove the principle of virtual work for a system of coplanar forces at different points of a rigid body in one plane. [L4; CLO2,3] | 05 |
| 3. | (a) | A body rests in equilibrium upon another fixed body, the position of the two bodies in contact being of radius r and R, respectively and the straight line joining the centers of the spheres being vertical if the first body be slightly displaced to find whether the equilibrium is stable or unstable. The surface being rough enough to prevent sliding. [L6; CLO2,3] | 05 |
| | (b) | A solid frustum of a paraboloid of revolution of height h and latus rectum 4a, rests with its vertex on the vertex of a paraboloid of revolution, where latus rectum is 4b show that the equilibrium is stable if $h < \frac{3ab}{a+b}$. [L2; CLO3] | 05 |
| 4. | (a) | Estimate the center of gravity of a lamina in the shape of quadrant of the curve $\left(\frac{x}{a}\right)^{2/3} + \left(\frac{y}{b}\right)^{2/3} = 1$; [L5; CLO4] | 05 |
| | (b) | Find the center of gravity of the area of the parabola $y^2 = 4ax$ between the axis of y and the ordinate $x = h$. [L5; CLO4] | 05 |

Section-B

There are **FOUR** questions in this section. Answer any **THREE** questions

- | | | | |
|----|-----|---|----|
| 5. | (a) | A particle moves in a straight line under an attraction towards a fixed point on the line and the force varies inversely as the square of the distance from the fixed point, discuss the motion. [L2; CLO2] | 05 |
| | (b) | A point moves in a straight line towards a center force $\frac{\mu}{(\text{distance})^3}$ starting from rest at a distance a from the center of force. Show that the time of reaching a point distance b from the center of force is $\frac{a\sqrt{a^2-b^2}}{\sqrt{\mu}}$ and that its velocity then is $\frac{\sqrt{\mu}\sqrt{a^2-b^2}}{ab}$. [L2; CLO5] | 05 |
| 6. | (a) | If the velocity of a particle along and perpendicular to the radius from a fixed origin are λr and $\mu \theta$, then find the path and show that the acceleration, along and perpendicular to the radius vector are $\lambda^2 r - \frac{\mu^2 \theta^2}{r}$ and $\mu \theta \left(\lambda + \frac{\mu}{r} \right)$. [L5; CLO5] | 05 |
| | (b) | A smooth straight thin tube revolves with angular velocity w in a vertical plane about one extremity which is fixed; if at zero time a particle inside it be at a distance 'a' from the fixed end and moving with velocity V along the tube, show that its distance at time t is $a \cosh(wt) + \left(\frac{V}{w} - \frac{g}{2w^2} \right) \sinh(wt) + \frac{g}{2w^2} \sin(wt)$. [L5; CLO2] | 05 |

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7. (a) If a particle moves with central acceleration $\frac{\mu}{(\text{distance})^3}$, then find the equation of path and distinguish the cases of different values of constants h and μ . [L6; CLO6] 05
- (b) Find the law of force towards the pole under which the curve $r^n = a^n \cos n \theta$ can be described. [L5; CLO4,5] 05
8. (a) A particle of unit mass is projected with velocity u at an inclination α above the horizon in a medium resistance is k time the velocity. Show that its direction will again make an angle α with the horizon after a time $\frac{1}{k} \log \left\{ 1 + \frac{2ku}{g} \sin \alpha \right\}$. [L2; CLO7] 05
- (b) Deduce the moment of inertia of the rectangular parallelopiped of edges $2a$, $2b$ and $2c$ and mass M and about a line (axis) through its center and parallel to one of its edge. [L5; CLO8] 05

***** THE END *****

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 Year: **Third**, Term: **II** Examination-2026; Session: **2024-2025**
 Course Code: **0541 12 Math 3205**
 Course Title: **Graph Theory**



Total Marks: **60**, Time: **03** Hours, Credit: **03**

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Section-A

There are **FOUR** questions in this section. Answer any **THREE** questions

		Marks
1.	(a) Define bipartite graph, pendant edge, and regular graph with examples. [L1; CLO1]	03
	(b) Prove that a simple graph with n vertices can have at most $\frac{n(n-1)}{2}$ edges. Further, if the graph consists of k connected components, determine the maximum possible number of edges it can have, and justify your result mathematically. [L5; CLO1]	04
	(c) Show that if the intersection of two paths in a graph is disconnected, then the union of the two paths contains at least one circuit. [L2; CLO1]	03
2.	(a) Define tree, spanning tree, and fundamental circuits. [L1; CLO2]	03
	(b) Prove that a tree with n vertices has exactly $n - 1$ edges. [L4; CLO2]	04
	(c) Show that a graph with n vertices, e edges, and k connected components has $e - n + k$ fundamental circuits. [L5; CLO2]	03
3.	(a) Define cut-sets and cut-vertices of a connected graph. [L1; CLO3]	02
	(b) Prove that every circuit has an even number of edges in common with any cut-set. [L5; CLO3]	04
	(c) Show that, with respect to a spanning tree T , a branch b that defines a fundamental cut-set S appears in every fundamental circuit associated with the chords of T that belong to S , and in no other fundamental circuit. [L4; CLO3]	04
4.	(a) Define a planar graph. Can a disconnected graph be planar? Justify your answer. [L2; CLO6]	03
	(b) State and prove Euler theorem for planar graphs. [L3; CLO6]	04
	(c) Prove that the complete graph with five vertices is nonplanar. [L4; CLO6]	03

Section-B

There are **FOUR** questions in this section. Answer any **THREE** questions

5.	(a) Define vector space of a graph. How can the vector space of a graph be represented over the Galois Field modulo 2? [L3; CLO4]	03
	(b) Prove that the set consisting of all the circuits and the edge-disjoint unions of circuits (including the null set $\emptyset$) in a graph G forms an abelian group under the ring sum operation. [L5; CLO4]	04
	(c) Show that the set of circuit vectors corresponding to the set of fundamental circuits of a connected graph with respect to any spanning tree forms a basis for its circuit subspace. [L4; CLO4]	03
6.	(a) Define incidence matrix and adjacency matrix of a graph. [L1; CLO5]	03
	(b) Find the rank of the incidence matrix of a graph. [L3; CLO5]	03
	(c) Establish the relation among A_f , B_f and C_f ; where the symbols have their usual meanings. [L5; CLO5]	04
7.	(a) Show that an n -vertex graph is a tree if and only if its chromatic polynomial is $P_n(\lambda) = \lambda(\lambda - 1)^{n-1}$. [L5; CLO4]	05
	(b) Show that a covering g of a graph is minimal if and only if g contains no paths of length three or more. [L5; CLO4]	05

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8. (a) Define: Isomorphic diagrams, simple diagrams, asymmetric diagrams and symmetric diagrams with their respective examples. [L1; CLO5] 05
- (b) Prove that a diagram G is acyclic if and only if its vertices can be ordered such that the adjacency matrix X is an upper (or lower) triangular matrix. [L5; CLO6] 05

***** THE END *****

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Year: **Third**, Term: **II** Examination-2026; Session: **2024-2025**

Course Code: **0541 12 Math 1103**

Course Title: **Differential Calculus**

Total Marks: **60**, Time: **03** Hours, Credit: **03**



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Section-A

There are **FOUR** questions in this section. Answer any **THREE** questions

- | | | Marks |
|----|---|--------------|
| 1. | (a) Draw the graphs of the functions $10^x, 3^x, 2^x, 10^{-x}, 3^{-x}, 2^{-x}$ in the same diagram and make a comparison with them. [L2; CLO1] | 04 |
| | (b) Discuss the continuity and differentiability of $f(x) = x-1 + x+3 $ at the point $x = -3$. [L6; CLO1] | 03 |
| | (c) Define the limit of a function $f(x)$ as x approaches a point a . Using the $\epsilon - \delta$ definition of a limit, prove that $\lim_{x \rightarrow 0} \left[x^3 \cos \frac{1}{x} \right] = 0$. [L1; CLO1] | 03 |
| 2. | (a) Write down the geometrical interpretation of derivative. [L1; CLO2] | 03 |
| | (b) Explain the continuity and differentiability of the function $f(x)$ at $x = 1$, where $f(x) = \begin{cases} x^2 + 1 & \text{if } x \leq 1 \\ 3x - 1 & \text{if } x > 1 \end{cases}$ Support your explanation by checking the necessary conditions for continuity and differentiability. [L2; CLO2] | 04 |
| | (c) Find $\frac{dy}{dx}$ of the given equation $x^y + y^x = 2^7$. [L1; CLO2] | 03 |
| 3. | (a) State Leibnitz's theorem. [L1; CLO3] | 02 |
| | (b) If $y = e^{a \sin^{-1} x}$, then by using Leibnitz's theorem prove that $(1-x^2)y_{n+2} - (2n+1)xy_{n+1} - (n^2 + a^2)y_n = 0$. Hence find $(y_n)_0$ i.e., the value of y_n when $x = 0$. [L5; CLO3] | 04 |
| | (c) By using Euler's theorem show that $x \frac{\partial u}{\partial x} + y \frac{\partial u}{\partial y} = 3 \tan u$, when $\sin x = \frac{x^2 y^2}{x+y}$. [L5; CLO3] | 04 |
| 4. | (a) Define a homogeneous function. State and derive Euler's theorem for a homogeneous function. [L5; CLO3] | 05 |
| | (b) If $u = \ln \left(\frac{x^2 + y^2}{x+y} \right)$ prove that $x \frac{\partial^2 u}{\partial x^2} + y \frac{\partial^2 u}{\partial y^2} + \frac{\partial u}{\partial x} + \frac{\partial u}{\partial y} = 0$. [L5; CLO3] | 05 |

Section-B

There are **FOUR** questions in this section. Answer any **THREE** questions

- | | | |
|----|---|-----------|
| 5. | (a) Verify the Mean-Value theorem satisfied on the given interval $[-5, 3]$ and find all values of $c \in (-5, 3)$ which satisfy the conclusion of the theorem for the function $f(x) = \sqrt{25-x^2}$, $\forall x \in [-5, 3]$. [L6; CLO4] | 05 |
| | (b) Verify Rolle's theorem for the function $f(x) = x^2 - 6x + 8$ on $[2, 4]$. [L6; CLO4] | 03 |
| | (c) Geometrically explain the constant difference theorem. [L2; CLO4] | 02 |

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6. (a) Use Maclaurin theorem to expand the function $f(x) = \frac{1}{1+x}$. [L2; CLO4] 03
- (b) Expand the function $\ln(1+x)$ in a Taylor series in the neighborhood $(2, \ln 3)$. [L2; CLO4] 04
- (c) Determine the equation of the tangent line to $r = 3 + 8\sin\theta$ at $\theta = \frac{\pi}{6}$. [L5; CLO5] 03
7. (a) Estimate the maximum and minimum values, if any, of the function $f(x) = x^4 + 2x^3 - 1$ on the open interval $(-\infty, +\infty)$. [L5; CLO6] 05
- (b) A closed cylindrical *can* is to hold 1 liter (1000 cm^3) of liquid. How should we choose the height and radius to minimize the amount of material needed to manufacture the *can*? [L4; CLO6] 05
8. (a) Find the point on the parabola $y = x^2 - 4x + 5$ where the curvature is maximum, and calculate the value of this maximum curvature. [L1; CLO6] 04
- (b) Obtain all vertical and horizontal asymptotes of the following function $f(x) = \frac{3x^2 - 2x + 1}{x^2 - 5x + 6}$ and determine the behavior of the graph near these asymptotes. [L6; CLO7] 03
- (c) Derive the pedal equation of the ellipse given by $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$. [L5; CLO7] 03

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 Course Code: **0541 12 Math 3209**
 Course Title: **Classical Mechanics**



Total Marks: **60**, Time: **03** Hours, Credit: **03**

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Section-A

There are **FOUR** questions in this section. Answer any **THREE** questions

		Marks
1.	(a) Explain classical mechanics in terms of Newton's laws of mechanics. [L1; CLO1]	03
	(b) State and prove D'Alembert's principle for a system of particles working on a body. [L5; CLO1]	04
	(c) Derive Lagrange's equation in Cartesian coordinates. [L3; CLO2]	03
2.	(a) Define generalized coordinates, holonomic and non-holonomic dynamical systems. Derive Lagrange's equation of motion for conservative and non-conservative systems. [L2; CLO2]	06
	(b) Discuss the advantages of Lagrangian mechanics over Newtonian mechanics. [L2; CLO1]	04
3.	(a) What is Routhian function? Derive modified Lagrange's equation of motion in terms of Routhian function. [L1; CLO2]	06
	(b) A particle is constraint to move on the plane curve $xy = c$. Obtain Lagrange's equation of motion. [L3; CLO3]	04
4.	(a) Describe the motion of a rigid body. Derive the equation of motion of a particle relative to the rotating earth in the form $\frac{d^2r}{dt^2} = g_e - 2\left(\underline{\omega} \wedge \frac{dr}{dt}\right)$, where the symbols have their usual meaning. [L1; CLO4]	05
	(b) A particle is projected vertically upwards with initial velocity v_0 . Prove that the points of fall will be at $\frac{4 v_0 ^3}{3g^2} \omega \cos \lambda$ to the west where ω =angular velocity, λ = latitude of the point considered. [L4; CLO4]	05

Section-B

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5.	(a) What is calculus of variation? State and prove the fundamental lemma of calculus of variations. [L5; CLO2]	05
	(b) State the Brachistochrone problem and obtain its solution using the calculus of variations. [L5; CLO2]	05
6.	(a) Define Hamiltonian function. If the Hamiltonian H does not depend explicitly on time t , prove that H is a constant of motion. [L3; CLO2]	03
	(b) Derive Hamilton's canonical equation of motion. [L4; CLO2]	03
	(c) What is phase space? Find Hamilton's equation of motion for compound pendulum. [L1; CLO2]	04
7.	(a) Describe the Lagrange and Poisson brackets. Establish a relation between the two brackets. [L3; CLO5]	06
	(b) Using Poisson bracket, show that the transformation $Q = (e^{-2q} - p^2)^2$ & $p = \cos^{-1}(pe^q)$ is canonical. [L5; CLO5]	04
8.	(a) What is relativity? Write the postulates of special relativity. [L1; CLO3]	02
	(b) Derive the Lorentz transformation equations between two inertial frames. [L5; CLO3]	03
	(c) Using Einstein's theory of special relativity, show that the relativistic mass m of a particle moving with velocity v is given by $m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$	05

where m_0 is the rest mass and c is the speed of light. Hence derive the mass-energy equivalence relation $E = mc^2$. [L6; CLO3]

***** THE END *****

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