

# SPACETIME AND GEOMETRY AN INTRODUCTION TO GENERAL RELATIVITY

GENERAL RELATIVITY EINSTEIN'S GENERAL THEORY OF RELATIVITY INTRODUCTION TO GENERAL RELATIVITY AN INTRODUCTION TO GENERAL RELATIVITY INTRODUCTION TO GENERAL RELATIVITY AND COSMOLOGY SPACETIME AND GEOMETRY GENERAL RELATIVITY FOR THE GIFTED AMATEUR EINSTEIN'S SPACE-TIME GENERAL RELATIVITY INTRODUCING GENERAL RELATIVITY MATHEMATICAL INTRODUCTION TO GENERAL RELATIVITY, A (SECOND EDITION) THE PHYSICAL AND MATHEMATICAL FOUNDATIONS OF THE THEORY OF RELATIVITY GRAVITY AN INTRODUCTION TO GENERAL RELATIVITY AND COSMOLOGY GENERAL RELATIVITY INTRODUCTION TO GENERAL RELATIVITY AND COSMOLOGY LECTURES ON GENERAL RELATIVITY ELEMENTS OF GENERAL RELATIVITY GENERAL RELATIVITY GENERAL THEORY OF RELATIVITY NORBERT STRAUMANN [\[?\]](#) YVIND GR [\[?\]](#) N JOHN DIRK WALECKA L. P. HUGHSTON CHRISTIAN G BOEHMER SEAN M. CARROLL TOM LANCASTER RAFAEL FERRARO STEVEN CARLIP MARK HINDMARSH AMOL SASANE ANTONIO ROMANO JAMES B. HARTLE JERZY PLEBANSKI ROBERT GEROCH CHRISTIAN G. B [\[?\]](#) HMER A. PAPAPETROU PIOTR T. CHRU [\[?\]](#) CIEL ROBERT M. WALD C. W. KILMISTER

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THE FOUNDATIONS ARE THOROUGHLY DEVELOPED TOGETHER WITH THE REQUIRED MATHEMATICAL BACKGROUND FROM DIFFERENTIAL GEOMETRY DEVELOPED IN PART III THE AUTHOR ALSO DISCUSSES THE TESTS OF GENERAL RELATIVITY IN DETAIL INCLUDING BINARY PULSARS WITH MUCH SPACE IS DEVOTED TO THE STUDY OF COMPACT OBJECTS ESPECIALLY TO NEUTRON STARS AND TO THE BASIC LAWS OF BLACK HOLE PHYSICS THIS WELL STRUCTURED TEXT AND REFERENCE ENABLES READERS TO EASILY NAVIGATE THROUGH THE VARIOUS SECTIONS AS BEST MATCHES THEIR BACKGROUNDS AND PERSPECTIVES WHETHER MATHEMATICAL PHYSICAL OR ASTRONOMICAL VERY APPLICATIONS ORIENTED THE TEXT INCLUDES VERY RECENT RESULTS SUCH AS THE SUPERMASSIVE BLACK HOLE IN OUR GALAXY AND FIRST DOUBLE PULSAR SYSTEM

THIS BOOK INTRODUCES THE GENERAL THEORY OF RELATIVITY AND INCLUDES APPLICATIONS TO COSMOLOGY THE BOOK PROVIDES A THOROUGH INTRODUCTION TO TENSOR CALCULUS AND CURVED MANIFOLDS AFTER THE NECESSARY MATHEMATICAL TOOLS ARE INTRODUCED THE AUTHORS OFFER A THOROUGH PRESENTATION OF THE THEORY OF RELATIVITY ALSO INCLUDED ARE SOME ADVANCED TOPICS NOT PREVIOUSLY COVERED BY TEXTBOOKS INCLUDING KALUZA KLEIN THEORY ISRAEL S FORMALISM AND BRANES ANISOTROPIC COSMOLOGICAL MODELS ARE ALSO INCLUDED THE BOOK CONTAINS A LARGE NUMBER OF NEW EXERCISES AND EXAMPLES EACH WITH SEPARATE HEADINGS THE READER WILL BENEFIT FROM AN UPDATED INTRODUCTION TO GENERAL RELATIVITY INCLUDING THE MOST RECENT DEVELOPMENTS IN COSMOLOGY

A WORKING KNOWLEDGE OF EINSTEIN S THEORY OF GENERAL RELATIVITY IS AN ESSENTIAL TOOL FOR EVERY PHYSICIST TODAY THIS SELF CONTAINED BOOK IS AN INTRODUCTORY TEXT ON THE SUBJECT AIMED AT FIRST YEAR GRADUATE STUDENTS OR ADVANCED UNDERGRADUATES IN PHYSICS THAT ASSUMES ONLY A BASIC UNDERSTANDING OF CLASSICAL LAGRANGIAN MECHANICS THE MECHANICS PROBLEM OF A POINT MASS CONSTRAINED TO MOVE WITHOUT FRICTION ON A TWO DIMENSIONAL SURFACE OF ARBITRARY SHAPE SERVES AS A PARADIGM FOR THE DEVELOPMENT OF THE MATHEMATICS AND PHYSICS OF GENERAL RELATIVITY AFTER REVIEWING SPECIAL RELATIVITY THE BASIC PRINCIPLES OF GENERAL RELATIVITY ARE PRESENTED AND THE MOST IMPORTANT APPLICATIONS ARE DISCUSSED THE FINAL SPECIAL TOPICS SECTION GUIDES THE READER THROUGH A FEW IMPORTANT AREAS OF CURRENT RESEARCH THIS BOOK WILL ALLOW THE READER TO APPROACH THE MORE ADVANCED TEXTS AND MONOGRAPHS AS WELL AS THE CONTINUAL INFLUX OF FASCINATING NEW EXPERIMENTAL RESULTS WITH A DEEPER UNDERSTANDING AND SENSE OF APPRECIATION

THIS TEXTBOOK PROVIDES AN INTRODUCTION TO GENERAL RELATIVITY FOR MATHEMATICS UNDERGRADUATES OR GRADUATE PHYSICISTS AFTER A REVIEW OF CARTESIAN TENSOR NOTATION AND SPECIAL RELATIVITY THE CONCEPTS OF RIEMANNIAN DIFFERENTIAL GEOMETRY ARE INTRODUCED MORE EMPHASIS IS PLACED ON AN INTUITIVE GRASP OF THE SUBJECT AND A CALCULATIONAL FACILITY THAN ON A RIGOROUS MATHEMATICAL EXPOSITION GENERAL RELATIVITY IS THEN PRESENTED AS A RELATIVISTIC THEORY OF GRAVITY REDUCING IN THE APPROPRIATE LIMITS TO NEWTONIAN GRAVITY OR SPECIAL RELATIVITY THE SCHWARZCHILD SOLUTION IS DERIVED AND THE GRAVITATIONAL RED SHIFT TIME DILATION AND CLASSIC TESTS OF GENERAL RELATIVITY ARE DISCUSSED THERE IS A BRIEF ACCOUNT OF GRAVITATIONAL COLLAPSE AND BLACK HOLES BASED ON THE EXTENDED SCHWARZCHILD SOLUTION OTHER VACUUM SOLUTIONS ARE DESCRIBED MOTIVATED BY THEIR COUNTERPARTS IN LINEARISED GENERAL RELATIVITY THE BOOK ENDS WITH CHAPTERS ON COSMOLOGICAL SOLUTIONS TO THE FIELD EQUATIONS THERE ARE EXERCISES ATTACHED TO EACH CHAPTER SOME OF WHICH EXTEND THE DEVELOPMENT GIVEN IN THE TEXT

INTRODUCTION TO GENERAL RELATIVITY AND COSMOLOGY GIVES UNDERGRADUATE STUDENTS AN OVERVIEW OF THE FUNDAMENTAL IDEAS BEHIND THE GEOMETRIC THEORY OF GRAVITATION AND SPACETIME THROUGH POINTERS ON HOW TO MODIFY AND GENERALISE EINSTEIN S THEORY TO ENHANCE UNDERSTANDING IT PROVIDES A LINK BETWEEN STANDARD TEXTBOOK CONTENT AND CURRENT RESEARCH IN THE FIELD CHAPTERS PRESENT COMPLICATED MATERIAL PRACTICALLY AND CONCISELY INITIALLY DEALING WITH THE MATHEMATICAL FOUNDATIONS OF THE THEORY OF RELATIVITY IN PARTICULAR DIFFERENTIAL GEOMETRY THIS IS FOLLOWED BY A DISCUSSION OF THE EINSTEIN FIELD EQUATIONS AND THEIR VARIOUS PROPERTIES ALSO GIVEN IS ANALYSIS OF THE IMPORTANT SCHWARZSCHILD SOLUTIONS FOLLOWED BY APPLICATION OF GENERAL RELATIVITY TO COSMOLOGY QUESTIONS WITH FULLY WORKED ANSWERS ARE PROVIDED AT THE END OF EACH CHAPTER TO AID COMPREHENSION AND GUIDE LEARNING THIS PARED DOWN TEXTBOOK IS SPECIFICALLY DESIGNED FOR NEW STUDENTS LOOKING FOR A WORKABLE SIMPLE PRESENTATION OF SOME OF THE KEY THEORIES IN MODERN PHYSICS AND MATHEMATICS

AN ACCESSIBLE INTRODUCTORY TEXTBOOK ON GENERAL RELATIVITY COVERING THE THEORY S FOUNDATIONS MATHEMATICAL FORMALISM AND MAJOR APPLICATIONS

GENERAL RELATIVITY IS ONE OF THE MOST PROFOUND STATEMENTS IN SCIENCE IT IS A THEORY OF GRAVITY THAT ALLOWS US TO MODEL THE LARGE SCALE STRUCTURE OF THE UNIVERSE TO UNDERSTAND AND EXPLAIN THE MOTIONS AND WORKINGS OF STARS TO REVEAL HOW GRAVITY INTERACTS WITH LIGHT WAVES AND EVEN HOW IT HOSTS ITS OWN GRAVITATIONAL WAVES IT IS

CENTRAL TO OUR NOTIONS OF WHERE THE UNIVERSE COMES FROM AND WHAT ITS EVENTUAL FATE MIGHT BE FOR THOSE WISHING TO LEARN PHYSICS GENERAL RELATIVITY ENJOYS A DUBIOUS DISTINCTION IT IS FREQUENTLY VIEWED AS A DIFFICULT THEORY WHOSE MASTERY IS A RITE OF PASSAGE INTO THE WORLD OF ADVANCED PHYSICS AND IS DESCRIBED IN AN ARRAY OF UNFORGIVING WEIGHTY TEXTBOOKS AIMED FIRMLY AT ASPIRING PROFESSIONALS WRITTEN BY EXPERIMENTAL PHYSICISTS AND AIMED AT PROVIDING THE INTERESTED AMATEUR WITH A BRIDGE FROM UNDERGRADUATE PHYSICS TO GENERAL RELATIVITY THIS BOOK IS DESIGNED TO BE DIFFERENT THE IMAGINED READER IS A GIFTED AMATEUR POSSESSING A CURIOUS AND ADAPTABLE MIND LOOKING TO BE TOLD AN ENTERTAINING AND INTELLECTUALLY STIMULATING STORY BUT WHO WILL NOT FEEL PATRONISED IF A FEW MATHEMATICAL NICETIES ARE SPELLED OUT IN DETAIL USING NUMEROUS WORKED EXAMPLES DIAGRAMS AND CAREFUL PHYSICALLY MOTIVATED EXPLANATIONS THIS BOOK WILL SMOOTH THE PATH TOWARDS UNDERSTANDING THE RADICALLY DIFFERENT AND REVOLUTIONARY VIEW OF THE PHYSICAL WORLD THAT GENERAL RELATIVITY PROVIDES AND WHICH ALL PHYSICISTS SHOULD HAVE THE OPPORTUNITY TO EXPERIENCE

THIS EXCELLENT TEXTBOOK OFFERS A UNIQUE TAKE ON RELATIVITY THEORY SETTING IT IN ITS HISTORICAL CONTEXT IDEAL FOR THOSE INTERESTED IN RELATIVITY AND THE HISTORY OF PHYSICS THE BOOK CONTAINS A COMPLETE ACCOUNT OF SPECIAL RELATIVITY THAT BEGINS WITH THE HISTORICAL ANALYSIS OF THE REASONS THAT LED TO A CHANGE IN OUR VIEW OF SPACE AND TIME ITS AIM IS TO FOSTER A DEEP UNDERSTANDING OF RELATIVISTIC SPACETIME AND ITS CONSEQUENCES FOR DYNAMICS

EINSTEIN S GENERAL THEORY OF RELATIVITY CURRENTLY OUR BEST THEORY OF GRAVITY IS IMPORTANT NOT ONLY TO SPECIALISTS BUT TO A MUCH WIDER GROUP OF PHYSICISTS THIS SHORT TEXTBOOK ON GENERAL RELATIVITY AND GRAVITATION OFFERS STUDENTS GLIMPSES OF THE VAST LANDSCAPE OF SCIENCE CONNECTED TO GENERAL RELATIVITY IT INCORPORATES SOME OF THE LATEST RESEARCH IN THE FIELD THE BOOK IS AIMED AT READERS WITH A BROAD RANGE OF INTERESTS IN PHYSICS FROM COSMOLOGY TO GRAVITATIONAL RADIATION TO HIGH ENERGY PHYSICS TO CONDENSED MATTER THEORY THE PEDAGOGICAL APPROACH IS PHYSICS FIRST READERS MOVE VERY QUICKLY TO THE CALCULATION OF OBSERVATIONAL PREDICTIONS AND ONLY RETURN TO THE MATHEMATICAL FOUNDATIONS AFTER THE PHYSICS IS ESTABLISHED IN ADDITION TO THE STANDARD TOPICS COVERED BY MOST INTRODUCTORY TEXTBOOKS IT CONTAINS SHORT INTRODUCTIONS TO MORE ADVANCED TOPICS FOR INSTANCE WHY FIELD EQUATIONS ARE SECOND ORDER HOW TO TREAT GRAVITATIONAL ENERGY AND WHAT IS REQUIRED FOR A HAMILTONIAN FORMULATION OF GENERAL RELATIVITY A CONCLUDING CHAPTER DISCUSSES DIRECTIONS FOR FURTHER STUDY FROM MATHEMATICAL RELATIVITY TO EXPERIMENTAL TESTS TO QUANTUM GRAVITY THIS IS AN INTRODUCTORY TEXT BUT IT HAS ALSO BEEN WRITTEN AS A JUMPING OFF POINT FOR READERS WHO PLAN TO STUDY MORE SPECIALIZED TOPICS

INTRODUCING GENERAL RELATIVITY AN ACCESSIBLE AND ENGAGING INTRODUCTION TO GENERAL RELATIVITY FOR UNDERGRADUATES IN INTRODUCING GENERAL RELATIVITY THE AUTHORS DELIVER A STRUCTURED INTRODUCTION TO THE CORE CONCEPTS AND APPLICATIONS OF GENERAL RELATIVITY THE BOOK LEADS READERS FROM THE BASIC IDEAS OF RELATIVITY INCLUDING THE EQUIVALENCE PRINCIPLE AND CURVED SPACE TIME TO MORE ADVANCED TOPICS LIKE SOLAR SYSTEM TESTS AND GRAVITATIONAL WAVE DETECTION EACH CHAPTER CONTAINS PRACTICE PROBLEMS DESIGNED TO ENGAGE UNDERGRADUATE STUDENTS OF MECHANICS ELECTRODYNAMICS AND SPECIAL RELATIVITY A WIDE RANGE OF CLASSICAL AND MODERN TOPICS ARE COVERED IN DETAIL FROM EXPLORING OBSERVATIONAL SUCCESSES AND ASTROPHYSICAL IMPLICATIONS TO EXPLAINING MANY POPULAR PRINCIPLES LIKE SPACE TIME REDSHIFT BLACK HOLES GRAVITATIONAL WAVES AND COSMOLOGY ADVANCED TOPIC SECTIONS INTRODUCE THE READER TO MORE DETAILED MATHEMATICAL APPROACHES AND COMPLEX IDEAS AND PREPARE THEM FOR THE EXPLORATION OF MORE SPECIALIZED AND SOPHISTICATED TEXTS INTRODUCING GENERAL RELATIVITY ALSO OFFERS STRUCTURED OUTLINES TO THE CONCEPTS OF GENERAL RELATIVITY AND A WIDE VARIETY OF ITS APPLICATIONS COMPREHENSIVE EXPLORATIONS OF FOUNDATIONAL IDEAS IN GENERAL RELATIVITY INCLUDING SPACE TIME CURVATURE AND TENSOR CALCULUS PRACTICAL DISCUSSIONS OF CLASSICAL AND MODERN TOPICS IN RELATIVITY FROM SPACE TIME TO REDSHIFT GRAVITY BLACK HOLES AND GRAVITATIONAL WAVES OPTIONAL IN DEPTH SECTIONS COVERING THE MATHEMATICAL APPROACHES TO MORE ADVANCED IDEAS PERFECT FOR UNDERGRADUATE PHYSICS STUDENTS WHO HAVE STUDIED MECHANICS DYNAMICS AND SPECIAL RELATIVITY INTRODUCING GENERAL RELATIVITY IS AN ESSENTIAL RESOURCE FOR THOSE SEEKING AN INTERMEDIATE LEVEL DISCUSSION OF GENERAL RELATIVITY PLACED BETWEEN THE MORE QUALITATIVE BOOKS AND GRADUATE LEVEL TEXTBOOKS

THE BOOK AIMS TO GIVE A MATHEMATICAL PRESENTATION OF THE THEORY OF GENERAL RELATIVITY THAT IS SPACETIME GEOMETRY BASED GRAVITATION THEORY TO ADVANCED UNDERGRADUATE MATHEMATICS STUDENTS MATHEMATICIANS WILL FIND SPACETIME PHYSICS PRESENTED IN THE DEFINITION THEOREM PROOF FORMAT FAMILIAR TO THEM THE GIVEN PRECISE MATHEMATICAL DEFINITIONS OF PHYSICAL NOTIONS HELP AVOIDING PITFALLS ESPECIALLY IN THE CONTEXT OF SPACETIME PHYSICS DESCRIBING PHENOMENA THAT ARE COUNTER INTUITIVE TO EVERYDAY EXPERIENCES IN THE FIRST PART THE DIFFERENTIAL GEOMETRY OF SMOOTH MANIFOLDS WHICH IS NEEDED TO PRESENT THE SPACETIME BASED GRAVITATION THEORY IS DEVELOPED FROM SCRATCH HERE MANY OF THE ILLUSTRATING EXAMPLES ARE THE LORENTZIAN MANIFOLDS WHICH LATER SERVE AS SPACETIME MODELS THIS HAS THE TWOFOLD PURPOSE OF MAKING THE PHYSICS FORTHCOMING IN THE SECOND PART RELATABLE AND THE MATHEMATICS LEARNT IN THE FIRST PART LESS DRY THE BOOK USES THE MODERN COORDINATE FREE LANGUAGE OF SEMI RIEMANNIAN GEOMETRY NEVERTHELESS TO FAMILIARISE THE READER WITH THE USEFUL TOOL OF COORDINATES FOR COMPUTATIONS AND TO BRIDGE THE GAP WITH THE PHYSICS LITERATURE THE LINK TO COORDINATES IS MADE THROUGH

EXERCISES AND VIA FREQUENT REMARKS ON HOW THE TWO LANGUAGES ARE RELATED IN THE SECOND PART THE FOCUS IS ON PHYSICS COVERING ESSENTIAL MATERIAL OF THE 20TH CENTURY SPACETIME BASED VIEW OF GRAVITY ENERGY MOMENTUM TENSOR FIELD OF MATTER FIELD EQUATION SPACETIME EXAMPLES NEWTONIAN APPROXIMATION GEODESICS TESTS OF THE THEORY BLACK HOLES AND COSMOLOGICAL MODELS OF THE UNIVERSE PRIOR KNOWLEDGE OF DIFFERENTIAL GEOMETRY OR PHYSICS IS NOT ASSUMED THE BOOK IS INTENDED FOR SELF STUDY AND THE SOLUTIONS TO ALL THE 283 EXERCISES ARE INCLUDED THE SECOND EDITION CORRECTS ERRORS FROM THE FIRST EDITION AND INCLUDES 60 NEW EXERCISES 10 NEW REMARKS 29 NEW FIGURES SOME OF WHICH COVER AUXILIARY TOPICS THAT WERE OMITTED IN THE FIRST EDITION

THIS UNIQUE TEXTBOOK OFFERS A MATHEMATICALLY RIGOROUS PRESENTATION OF THE THEORY OF RELATIVITY EMPHASIZING THE NEED FOR A CRITICAL ANALYSIS OF THE FOUNDATIONS OF GENERAL RELATIVITY IN ORDER TO BEST STUDY THE THEORY AND ITS IMPLICATIONS THE TRANSITIONS FROM CLASSICAL MECHANICS TO SPECIAL RELATIVITY AND THEN TO GENERAL RELATIVITY ARE EXPLORED IN DETAIL AS WELL HELPING READERS TO GAIN A MORE PROFOUND AND NUANCED UNDERSTANDING OF THE THEORY AS A WHOLE AFTER REVIEWING THE FUNDAMENTALS OF DIFFERENTIAL GEOMETRY AND CLASSICAL MECHANICS THE TEXT INTRODUCES SPECIAL RELATIVITY FIRST USING THE PHYSICAL APPROACH PROPOSED BY EINSTEIN AND THEN VIA MINKOWSKI S MATHEMATICAL MODEL THE AUTHORS THEN ADDRESS THE RELATIVISTIC THERMODYNAMICS OF CONTINUA AND ELECTROMAGNETIC FIELDS IN MATTER TOPICS WHICH ARE NORMALLY COVERED ONLY VERY BRIEFLY IN OTHER TREATMENTS IN THE NEXT TWO CHAPTERS THE TEXT THEN TURNS TO A DISCUSSION OF GENERAL RELATIVITY BY MEANS OF THE AUTHORS UNIQUE CRITICAL APPROACH UNDERLINING THE DIFFICULTY OF RECOGNIZING THE PHYSICAL MEANING OF SOME STATEMENTS SUCH AS THE PHYSICAL MEANING OF COORDINATES AND THE DERIVATION OF PHYSICAL QUANTITIES FROM THOSE OF SPACE TIME CHAPTERS IN THIS SECTION COVER THE MODEL OF SPACE TIME PROPOSED BY SCHWARZSCHILD BLACK HOLES THE FRIEDMAN EQUATIONS AND THE DIFFERENT COSMOLOGICAL MODELS THEY DESCRIBE AND THE FERMI WALKER DERIVATIVE WELL SUITED FOR GRADUATE STUDENTS IN PHYSICS AND MATHEMATICS WHO HAVE A STRONG FOUNDATION IN REAL ANALYSIS CLASSICAL MECHANICS AND GENERAL PHYSICS THIS TEXTBOOK IS APPROPRIATE FOR A VARIETY OF GRADUATE LEVEL COURSES THAT COVER TOPICS IN RELATIVITY ADDITIONALLY IT WILL INTEREST PHYSICISTS AND OTHER RESEARCHERS WHO WISH TO FURTHER STUDY THE SUBTLETIES OF THESE THEORIES AND UNDERSTAND THE CONTEMPORARY SCHOLARLY DISCUSSIONS SURROUNDING THEM

PROVIDING RELEVANT SOLUTIONS OF THE EINSTEIN EQUATION THIS TEXT INTRODUCES FIELD EQUATIONS OF GENERAL RELATIVITY THEIR SUPPORTING MATHEMATICS EMPHASIS IS ON THE CONNECTION BETWEEN OBSERVATION THEORY AND THE PHENOMENA OF GRAVITATIONAL PHYSICS

EXPERTS INTRODUCE THE TOOLS OF GR AND RELATIVISTIC COSMOLOGY GUIDING ADVANCED STUDENTS THROUGH COMPLETE DERIVATIONS OF THE RESULTS

ROBERT GEROCH'S LECTURE NOTES ON GENERAL RELATIVITY ARE UNIQUE IN THREE MAIN RESPECTS FIRST THE PHYSICS OF GENERAL RELATIVITY AND THE MATHEMATICS WHICH DESCRIBES IT ARE MASTERFULLY INTERTWINED IN SUCH A WAY THAT BOTH REINFORCE EACH OTHER TO FACILITATE THE UNDERSTANDING OF THE MOST ABSTRACT AND SUBTLE ISSUES SECOND THE PHYSICAL PHENOMENA ARE FIRST PROPERLY EXPLAINED IN TERMS OF SPACETIME AND THEN IT IS SHOWN HOW THEY CAN BE DECOMPOSED INTO FAMILIAR QUANTITIES EXPRESSED IN TERMS OF SPACE AND TIME WHICH ARE MEASURED BY AN OBSERVER THIRD GEROCH'S SUCCESSFUL PEDAGOGICAL APPROACH TO TEACHING THEORETICAL PHYSICS THROUGH VISUALIZATION OF EVEN THE MOST ABSTRACT CONCEPTS IS FULLY APPLIED IN HIS LECTURES ON GENERAL RELATIVITY BY THE USE OF AROUND A HUNDRED FIGURES ALTHOUGH THE BOOK CONTAINS LECTURE NOTES WRITTEN IN 1972 IT IS AND WILL REMAIN AN EXCELLENT INTRODUCTION TO GENERAL RELATIVITY WHICH COVERS ITS PHYSICAL FOUNDATIONS ITS MATHEMATICAL FORMALISM THE CLASSICAL TESTS OF ITS PREDICTIONS ITS APPLICATION TO COSMOLOGY A NUMBER OF SPECIFIC AND IMPORTANT ISSUES SUCH AS THE INITIAL VALUE FORMULATION OF GENERAL RELATIVITY SIGNAL PROPAGATION TIME ORIENTATION CAUSALITY VIOLATION SINGULARITY THEOREMS CONFORMAL TRANSFORMATIONS AND ASYMPTOTIC STRUCTURE OF SPACETIME AND THE EARLY APPROACHES TO QUANTIZATION OF THE GRAVITATIONAL FIELD GEROCH'S DIFFERENTIAL GEOMETRY 1972 LECTURE NOTES CAN SERVE AS A VERY HELPFUL COMPANION TO THIS BOOK

INTRODUCTION TO GENERAL RELATIVITY AND COSMOLOGY GIVES UNDERGRADUATE STUDENTS AN OVERVIEW OF THE FUNDAMENTAL IDEAS BEHIND THE GEOMETRIC THEORY OF GRAVITATION AND SPACETIME THROUGH POINTERS ON HOW TO MODIFY AND GENERALISE EINSTEIN'S THEORY TO ENHANCE UNDERSTANDING IT PROVIDES A LINK BETWEEN STANDARD TEXTBOOK CONTENT AND CURRENT RESEARCH IN THE FIELD CHAPTERS PRESENT COMPLICATED MATERIAL PRACTICALLY AND CONCISELY INITIALLY DEALING WITH THE MATHEMATICAL FOUNDATIONS OF THE THEORY OF RELATIVITY IN PARTICULAR DIFFERENTIAL GEOMETRY THIS IS FOLLOWED BY A DISCUSSION OF THE EINSTEIN FIELD EQUATIONS AND THEIR VARIOUS PROPERTIES ALSO GIVEN IS ANALYSIS OF THE IMPORTANT SCHWARZSCHILD SOLUTIONS FOLLOWED BY APPLICATION OF GENERAL RELATIVITY TO COSMOLOGY QUESTIONS WITH FULLY WORKED ANSWERS ARE PROVIDED AT THE END OF EACH CHAPTER TO AID COMPREHENSION AND GUIDE LEARNING THIS PARED DOWN TEXTBOOK IS SPECIFICALLY DESIGNED FOR NEW STUDENTS LOOKING FOR A WORKABLE SIMPLE PRESENTATION OF SOME OF THE KEY THEORIES IN MODERN PHYSICS AND MATHEMATICS

THIS BOOK IS AN ELABORATION OF LECTURE NOTES FOR THE GRADUATE COURSE ON GENERAL RELATIVITY GIVEN BY THE AUTHOR AT BOSTON UNIVERSITY IN THE SPRING SEMESTER OF 1972 IT IS AN INTRODUCTION TO THE SUBJECT ONLY AS THE TIME AVAILABLE FOR THE COURSE WAS LIMITED THE AUTHOR OF AN INTRODUCTION TO GENERAL RELATIVITY IS FACED FROM THE BEGINNING WITH THE DIFFICULT TASK OF CHOOSING WHICH MATERIAL TO INCLUDE A GENERAL CRITERION ASSISTING IN THIS CHOICE IS PROVIDED BY THE DIDACTIC CHARACTER OF THE BOOK THOSE CHAPTERS HAVE TO BE INCLUDED IN PRIORITY WHICH WILL BE MOST USEFUL TO THE READER IN ENABLING HIM TO UNDERSTAND THE METHODS USED IN GENERAL RELATIVITY THE RESULTS OBTAINED SO FAR AND POSSIBLY THE PROBLEMS STILL TO BE SOLVED THIS CRITERION IS NOT SUFFICIENT TO ENSURE A UNIQUE CHOICE GENERAL RELATIVITY HAS DEVELOPED TO SUCH A DEGREE THAT IT IS IMPOSSIBLE TO INCLUDE IN AN INTRODUCTORY TEXTBOOK OF A REASONABLE LENGTH EVEN A VERY CONDENSED TREATMENT OF ALL IMPORTANT PROBLEMS WHICH HAVE BEEN DISCUSSED UNTIL NOW AND THE AUTHOR IS OBLIGED TO DECIDE IN A MORE OR LESS SUBJECTIVE MANNER WHICH OF THE MORE RECENT DEVELOPMENTS TO OMIT THE FOLLOWING LINES INDICATE BY MEANS OF SOME EXAMPLES THE KIND OF CHOICE MADE IN THIS BOOK

THIS BOOK PROVIDES AN INTRODUCTION TO THE MATHEMATICS AND PHYSICS OF GENERAL RELATIVITY ITS BASIC PHYSICAL CONCEPTS ITS OBSERVATIONAL IMPLICATIONS AND THE NEW INSIGHTS OBTAINED INTO THE NATURE OF SPACE TIME AND THE STRUCTURE OF THE UNIVERSE IT INTRODUCES SOME OF THE MOST STRIKING ASPECTS OF EINSTEIN'S THEORY OF GRAVITATION BLACK HOLES GRAVITATIONAL WAVES STELLAR MODELS AND COSMOLOGY IT CONTAINS A SELF CONTAINED INTRODUCTION TO TENSOR CALCULUS AND RIEMANNIAN GEOMETRY USING IN PARALLEL THE LANGUAGE OF MODERN DIFFERENTIAL GEOMETRY AND THE COORDINATE NOTATION MORE FAMILIAR TO PHYSICISTS THE AUTHOR HAS STRIVED TO ACHIEVE MATHEMATICAL RIGOUR WITH ALL NOTIONS GIVEN CAREFUL MATHEMATICAL MEANING WHILE TRYING TO MAINTAIN THE FORMALISM TO THE MINIMUM FIT FOR PURPOSE FAMILIARITY WITH SPECIAL RELATIVITY IS ASSUMED THE OVERALL AIM IS TO CONVEY SOME OF THE MAIN PHYSICAL AND GEOMETRICAL PROPERTIES OF EINSTEIN'S THEORY OF GRAVITATION PROVIDING A SOLID ENTRY POINT TO FURTHER STUDIES OF THE MATHEMATICS AND PHYSICS OF EINSTEIN EQUATIONS

WALD'S BOOK IS CLEARLY THE FIRST TEXTBOOK ON GENERAL RELATIVITY WITH A TOTALLY MODERN POINT OF VIEW AND IT SUCCEEDS VERY WELL WHERE OTHERS ARE ONLY PARTIALLY SUCCESSFUL THE BOOK INCLUDES FULL DISCUSSIONS OF MANY PROBLEMS OF CURRENT INTEREST WHICH ARE NOT TREATED IN ANY EXISTANT BOOK AND ALL THESE MATTERS ARE CONSIDERED WITH PERCEPTION AND UNDERSTANDING S CHANDRASEKHAR A TOUR DE FORCE LUCID STRAIGHTFORWARD MATHEMATICALLY RIGOROUS EXACTING IN THE ANALYSIS OF THE THEORY IN ITS PHYSICAL ASPECT



L P HUGHSTON TIMES HIGHER EDUCATION SUPPLEMENT TRULY EXCELLENT A SOPHISTICATED TEXT OF MANAGEABLE SIZE THAT WILL PROBABLY BE READ BY EVERY STUDENT OF RELATIVITY  
ASTROPHYSICS AND FIELD THEORY FOR YEARS TO COME JAMES W YORK PHYSICS TODAY

GENERAL THEORY OF RELATIVITY DEALS WITH THE GENERAL THEORY OF RELATIVITY AND COVERS TOPICS RANGING FROM THE PRINCIPLE OF EQUIVALENCE AND THE SPACE THEORY OF MATTER TO  
THE HYPOTHESES WHICH LIE AT THE BASES OF GEOMETRY ALONG WITH THE EFFECT OF GRAVITATION ON THE PROPAGATION OF LIGHT THE MOTION OF PARTICLES IN GENERAL RELATIVITY THEORY  
IS ALSO DISCUSSED THIS BOOK IS COMPRISED OF 14 CHAPTERS AND BEGINS WITH A REVIEW OF THE PRINCIPLE OF EQUIVALENCE PAYING PARTICULAR ATTENTION TO THE QUESTION OF THE  
EXISTENCE OF INERTIAL FRAMES IN NEWTONIAN MECHANICS THE BEGINNINGS AND FOUNDATIONS OF GENERAL RELATIVITY ARE THEN CONSIDERED TOGETHER WITH MODERN DEVELOPMENTS IN THE FIELD  
SUBSEQUENT CHAPTERS EXPLORE THE GENERAL NOTION OF MULTIPLY EXTENDED MAGNITUDES THE SPACE THEORY OF MATTER THE EFFECT OF GRAVITATION ON LIGHT PROPAGATION GRAVITATIONAL  
WAVES AND THE MOTION OF PARTICLES IN GENERAL RELATIVITY THEORY AND HOMOGENEITY AND COVARIANCE AN INVARIANT FORMULATION OF GRAVITATIONAL RADIATION THEORY IS ALSO  
PRESENTED THE LAST THREE CHAPTERS EXAMINE CONTINUED GRAVITATIONAL CONTRACTION A SPINOR APPROACH TO GENERAL RELATIVITY AND GRAVITATIONAL RED SHIFT IN NUCLEAR RESONANCE  
THIS MONOGRAPH WILL BE OF INTEREST TO PHYSICISTS AND MATHEMATICIANS

RECOGNIZING THE HABIT WAYS TO ACQUIRE THIS EBOOK **SPACETIME AND GEOMETRY AN INTRODUCTION TO GENERAL RELATIVITY** IS ADDITIONALLY USEFUL. YOU HAVE REMAINED IN RIGHT SITE TO  
START GETTING THIS INFO. GET THE SPACETIME AND GEOMETRY AN INTRODUCTION TO GENERAL RELATIVITY LINK THAT WE FIND THE MONEY FOR HERE AND CHECK OUT THE LINK. YOU COULD  
PURCHASE LEAD SPACETIME AND GEOMETRY AN INTRODUCTION TO GENERAL RELATIVITY OR GET IT AS SOON AS FEASIBLE. YOU COULD SPEEDILY DOWNLOAD THIS SPACETIME AND GEOMETRY  
AN INTRODUCTION TO GENERAL RELATIVITY AFTER GETTING DEAL. SO, WHEN YOU REQUIRE THE EBOOK SWIFTLY, YOU CAN STRAIGHT ACQUIRE IT. ITS IN VIEW OF THAT TOTALLY EASY AND  
SUITABLY FATS, ISNT IT? YOU HAVE TO FAVOR TO IN THIS SKY

1. WHERE CAN I BUY SPACETIME AND GEOMETRY AN INTRODUCTION TO GENERAL RELATIVITY BOOKS? BOOKSTORES: PHYSICAL BOOKSTORES LIKE BARNES & NOBLE, WATERSTONES, AND INDEPENDENT LOCAL STORES.  
ONLINE RETAILERS: AMAZON, BOOK DEPOSITORY, AND VARIOUS ONLINE BOOKSTORES OFFER A BROAD SELECTION OF BOOKS IN PRINTED AND DIGITAL FORMATS.
2. WHAT ARE THE DIVERSE BOOK FORMATS AVAILABLE? WHICH TYPES OF BOOK FORMATS ARE CURRENTLY AVAILABLE? ARE THERE DIFFERENT BOOK FORMATS TO CHOOSE FROM? HARDCOVER: ROBUST AND RESILIENT,

USUALLY MORE EXPENSIVE. PAPERBACK: LESS COSTLY, LIGHTER, AND MORE PORTABLE THAN HARDCOVERS. E-BOOKS: DIGITAL BOOKS ACCESSIBLE FOR E-READERS LIKE KINDLE OR THROUGH PLATFORMS SUCH AS APPLE BOOKS, KINDLE, AND GOOGLE PLAY BOOKS.

3. HOW CAN I DECIDE ON A SPACETIME AND GEOMETRY AN INTRODUCTION TO GENERAL RELATIVITY BOOK TO READ? GENRES: TAKE INTO ACCOUNT THE GENRE YOU ENJOY (FICTION, NONFICTION, MYSTERY, SCI-FI, ETC.). RECOMMENDATIONS: ASK FOR ADVICE FROM FRIENDS, PARTICIPATE IN BOOK CLUBS, OR EXPLORE ONLINE REVIEWS AND SUGGESTIONS. AUTHOR: IF YOU LIKE A SPECIFIC AUTHOR, YOU MIGHT ENJOY MORE OF THEIR WORK.

4. HOW SHOULD I CARE FOR SPACETIME AND GEOMETRY AN INTRODUCTION TO GENERAL RELATIVITY BOOKS? STORAGE: STORE THEM AWAY FROM DIRECT SUNLIGHT AND IN A DRY SETTING. HANDLING: PREVENT FOLDING PAGES, UTILIZE BOOKMARKS, AND HANDLE THEM WITH CLEAN HANDS. CLEANING: OCCASIONALLY DUST THE COVERS AND PAGES GENTLY.

5. CAN I BORROW BOOKS WITHOUT BUYING THEM? PUBLIC LIBRARIES: REGIONAL LIBRARIES OFFER A WIDE RANGE OF BOOKS FOR BORROWING. BOOK SWAPS: COMMUNITY BOOK EXCHANGES OR WEB PLATFORMS WHERE PEOPLE SWAP BOOKS.

6. HOW CAN I TRACK MY READING PROGRESS OR MANAGE MY BOOK CLILECTION? BOOK TRACKING APPS: GOODREADS ARE POPOLAR APPS FOR TRACKING YOUR READING PROGRESS AND MANAGING BOOK CLILECTIONS. SPREADSHEETS: YOU CAN CREATE YOUR OWN SPREADSHEET TO TRACK BOOKS READ, RATINGS, AND OTHER DETAILS.

7. WHAT ARE SPACETIME AND GEOMETRY AN INTRODUCTION TO GENERAL RELATIVITY AUDIOBOOKS, AND WHERE CAN I FIND THEM? AUDIOBOOKS: AUDIO RECORDINGS OF BOOKS, PERFECT FOR LISTENING WHILE COMMUTING OR MOLTITASKING. PLATFORMS: LIBRIVOX OFFER A WIDE SELECTION OF AUDIOBOOKS.

8. HOW DO I SUPPORT AUTHORS OR THE BOOK INDUSTRY? BUY BOOKS: PURCHASE BOOKS FROM AUTHORS OR INDEPENDENT BOOKSTORES. REVIEWS: LEAVE REVIEWS ON PLATFORMS LIKE GOODREADS. PROMOTION: SHARE YOUR FAVORITE BOOKS ON SOCIAL MEDIA OR RECOMMEND THEM TO FRIENDS.

9. ARE THERE BOOK CLUBS OR READING COMMUNITIES I CAN JOIN? LOCAL CLUBS: CHECK FOR LOCAL BOOK CLUBS IN LIBRARIES OR COMMUNITY CENTERS. ONLINE COMMUNITIES: PLATFORMS LIKE BOOKBUB HAVE VIRTUAL BOOK CLUBS AND DISCUSSION GROUPS.

10. CAN I READ SPACETIME AND GEOMETRY AN INTRODUCTION TO GENERAL RELATIVITY BOOKS FOR FREE? PUBLIC DOMAIN BOOKS: MANY CLASSIC BOOKS ARE AVAILABLE FOR FREE AS THEYRE IN THE PUBLIC DOMAIN.

FREE E-BOOKS: SOME WEBSITES OFFER FREE E-BOOKS LEGALLY, LIKE PROJECT GUTENBERG OR OPEN LIBRARY. FIND SPACETIME AND GEOMETRY AN INTRODUCTION TO GENERAL RELATIVITY

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