

# **GENERAL RELATIVITY & COSMOLOGY**

A Quick Guide

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# **1 Overview and Review**

What is general relativity? It's a theory of gravity.

Replaces Newton's law of gravity, for heavy masses and high precision.

Keep in mind, GR is not compatible with Quantum Mechanics.

Question in Physics: how to reconcile GR and QM?

## **1.1 Review of Special Relativity**

## **1.2 The Equivalence Principle**

## **1.3 Versions of the Equivalence Principle**

### **1.3.1 The Strong Equivalence Principle**

### **1.3.2 The Weak Equivalence Principle**

## 2 Review of Multivariable and Vector Calculus

### 3 Flat 3-dimensional space

#### 3.1 Basis vectors

#### 3.2 Contravariant and covariant vectors

#### 3.3 Metric tensor

#### 3.4 Coordinate transformation

#### 3.5 Tensors

## 4 Flat spacetime

### 4.1 Special Relativity

### 4.2 Relativistic Electrodynamics

## 5 Curved spaces

### 5.1 2-dimensional curved spaces

### 5.2 Manifolds

### 5.3 Tensors on manifolds



## 6 Gravitation and Curvature

6.1 Geodesics and Affine connections  $\Gamma_{\mu\nu}^{\sigma}$

6.2 Parallel transport

6.3 Covariant differentiation

6.4 Newtonian limit

## 7 Einstein's field equations

7.1 The stress-energy tensor  $T^{\mu\nu}$

7.2 Riemann curvature tensor  $R^\lambda_{\mu\nu\sigma}$

7.3 The Einstein equations

7.4 Schwarzschild solution

## 8 Predictions and tests of general relativity

### 8.1 Gravitational redshift

### 8.2 Radar time-delay experiments

### 8.3 Black Holes

## 9 Cosmoslogy

### 9.1 The Friedman-Robertson-Walker solution

### 9.2 Hubble's “constant” $H(t)$

### 9.3 Recent discoveries in cosmology

### 9.4 The cosmological constant