The present investigations have been carried out towards the fulfillment of the requirements for the award of a Ph.D. degree in Physics of V.E.S. Purvanchal University, Jaunpur (U.P.), India, under the supervision of Dr. G.S. Dubey, Reader and Head, Department of Physics, G.S.P.G. College Samodhpur, Jaunpur (U.P.), India and co-supervision of Dr. K.S. Upadhyay, Reader and Head, Department of Physics, K.N. Gov. P.G. College Gyanpur, Sant Ravidas Nagar, Bhadohi (U.P.), India.

The thesis deals with quantum theory in external electromagnetic and gravitational fields. It has been divided into four chapters. The first chapter is introductory. So, we have formulated and discussed some of the techniques and results which are relevant for our subsequent investigations. Hence, we have presented, path integral methods, Kernels and ground-state expectation values, the effective action and the method of proper time.

In chapter II, we have presented quantum theory in external electromagnetic field, and obtained effective action from ground state energy, effective lagrangian from
path integral and renormalization of the effective action. The formalism developed in the chapter I are applied to the study of an important problem: the calculation of the effective action for electromagnetic fields which allows us-for example-to determine the quantum corrections to classical Maxwell equations. This study also reveals several important conceptual issues in our formalism. As a bonus we will be able to understand some aspects of the renormalization procedure in quantum electrodynamics. We have derived the form of the effective action and studied its real part.

In chapter III, we have investigated quantization in different gauges. We have presented the physical origin of the imaginary part to $L_{\text{eff}}$. The existence of an imaginary part to $L_{\text{eff}}$ suggests that the probability for the quantum system, the scalar field, to be in the ground state at $t = \infty$ is less than unity. As the excited states of the scalar field may be interpreted as states containing non-zero number of scalar quanta, this phenomenon may be thought of as particle creation by the electric field. Since the notion of a static electromagnetic field creating particles may be rather surprising, we have examined the origin of this phenomenon more closely. It is observed that there are
some interesting conceptual issues, connected with gauge invariance of this phenomenon, which needs to be scrutinized carefully. We have described a constant electric field in two different gauges, one in which the potential is time dependent and the other in which space dependent. Hence, we have studied, the quantum theory of the scalar field in these two gauges. The study reveals the essential differences and similarities in the quantization of the scalar field in two different gauges and we have compared these results. We have also considered quantum theory in a very different kind of background. These backgrounds, which involve description of nonsingular fields in singular gauges, occur both in electromagnetism and gravity. We have investigated the electromagnetic case.

In the last chapter we have investigated quantum theory in external gravitational field. We have also presented the analogies between quantum theory in an external electromagnetic field and quantum theory in a gravitational field. The discussion is based on three important features: (1) The formal correspondence between pair creation in a electric field and pair creation in cosmology, (2) A comparison between gauge invariance in electromagnetism and coordinate invariance in general
relativity, (3) The thermal effects which arise due to quantization in singular gauges. One of our aims is to compare the gauge invariance of the particle concept in electromagnetism with the coordinate invariance of the particle concept in gravity. Hence, we have studied the particle definition in two different gauges which represent a constant electric field and the particle definition in two different coordinate systems which represent a part of flat spacetime, and compared the results. It is shown that several peculiar features, like the ambiguity of particle definition, thermal effects etc. which are thought to be special to quantum theory in curved spacetime, have analogues in the case of electromagnetism.

Every chapter has been divided into sections following decimal system: i.e. section (1.4) means fourth section of chapter first. On the same line, the equations in different chapters are also numbered i.e. Eq. (4.4), means, fourth equation of chapter four. At last references are given.