The study of the co-existence of singlet superconductivity and ferromagnetism in bulk materials has been a long standing and intriguing problem in condensed matter physics since the superconductivity and ferromagnetism are quantum mechanically antagonistic to each other (i.e. parallel alignment of spins in the ferromagnet and Cooper pairs with oppositely aligned spins in the superconductor). Though it is incompatible to have the coexistence of singlet superconductivity and ferromagnetism in bulk compound, it is highly possible to artificially fabricate superconductor (S)/ferromagnet (F) heterostructures using various thin film deposition techniques and to study the interplay between the two antagonistic quantum phases over their characteristic length scales. The mutual interaction between the two competing order parameters at the interface in hybrid S/F heterostructures give rise to a variety of novel exotic physical phenomena. Moreover, the spin polarized transport and tunneling experiments in S/F heterostructures seem to be very much useful for providing important information on the spin dependent electronic properties of high $T_c$ superconductors below and above the transition temperature. This can help a lot to understand the long debated unusual electronic properties and pairing mechanism of high $T_c$ superconductors. In addition to the rich fundamental aspects buried in the study of S/F heterostructures, one can also use the spin dependent properties of high $T_c$ superconductors in S/F heterostructures to design new spintronics devices from the application point of view.

In this thesis an attempt is made to understand the spin polarized electron transport across S/F heterostructures where the superconductor used is $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ and the ferromagnets are $\text{La}_{0.5}\text{Sr}_{0.5}\text{CoO}_3$, $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3$, and $\text{La}_{0.7}\text{Ca}_{0.3}\text{MnO}_3$. In addition, the magnetic properties of the $\text{La}_{1-x}\text{Sr}_x\text{CoO}_3$ system is also investigated in detail.

The thesis is organized in six chapters and a brief summary of each chapter is given below.

**Chapter 1** gives a brief introduction to the superconductivity, ferromagnetism and the interplay between superconductivity and ferromagnetism at the interface of S/F heterostructures. It also describes various exotic phenomena and the proximity effect that emerges at the S/F interface due to competing interactions. In addition, it also includes a
discussion on various types of indirect magnetic interactions and basic idea about the spin glass ordering in magnetic materials.

Chapter 2 outlines the basic principles of various experimental techniques employed for the work presented in this thesis.

Chapter 3 describes an extensive magnetic and magnetotransport study of the La\(_{1-x}\)Sr\(_x\)CoO\(_3\) system to understand the manifestation of various magnetic phases associated with it. The first section of this chapter aims at understanding the phase separation scenario in La\(_{0.85}\)Sr\(_{0.15}\)CoO\(_3\). Since the magnetic behavior of La\(_{0.85}\)Sr\(_{0.15}\)CoO\(_3\) is in the border area of spin glass (SG) and ferromagnetic (F) region in the x-T phase diagram; it has been subjected to a controversial debate for the last several years; while some groups show evidence for magnetic phase separation (PS), others show SG behavior. However, the experimental results presented in this thesis clearly demonstrate that the instability towards PS with inhomogeneous states or competing phases in La\(_{0.85}\)Sr\(_{0.15}\)CoO\(_3\) is not inherent or intrinsic to this compound; rather it is a consequence of the heat treatment condition during the preparation method. It is realized that low temperature annealed sample shows PS whereas the high temperature annealed sample shows the characteristics of canonical SG behavior. The second section of this chapter deals with a detailed study about the possible existence of various magnetic phases of La\(_{1-x}\)Sr\(_x\)CoO\(_3\) in the range 0 ≤ x ≤ 0.5. The dc magnetization study for x ≥ 0.18 exhibits the characteristic of ferromagnetic like behavior and for x < 0.18, the SG behavior. More strikingly, the dc magnetization studies for x < 0.18 rules out the existence of any ferromagnetic correlation that gives rise to irreversible line in the spin glass regime. The ac susceptibility study for x < 0.18, exhibits a considerable frequency dependent peak shift, time-dependent memory effect, and the characteristic spin relaxation time scale τ\(_0\) ~ 10\(^{-13}\) s, all pointing towards the characteristics of SG behavior. On the other hand, the ac susceptibility study in the higher doping ferromagnetic side exhibits the coexistence of glassy and ferromagnetic behavior. The glassiness is interpreted in terms of inter-cluster interaction. The reciprocal susceptibility vs. T plot in the paramagnetic side adheres strictly to Curie-Weis behavior and does not provide any signature for the pre-formation of ferromagnetic clusters well above the Curie temperature. The magnetotransport study reveals a cross over from metallic behavior to semiconducting like behavior for x ≤ 0.18 and the system exhibits a
peak in MR in the vicinity of $T_c$ on the metallic side and a large value of MR at low temperature on the semiconducting side. Such high value of MR in the semiconducting spin glass regime is strongly believed due to spin dependent part of random potential distribution. Based on the present experimental findings, a revised phase diagram has been constructed and each phase has been characterized with its associated properties.

**Chapter 4** deals with a comprehensive study of thickness dependent structural, magnetic and magnetotransport properties of oriented $La_{0.5}Sr_{0.5}CoO_3$ thin films grown on $LaAlO_3$ by pulsed laser deposition. The films are found to undergo a reduction in Curie temperature with decrease in film thicknesses and it is primarily caused by the finite size effect since the finite scaling law holds good over the studied thickness range. The contribution from strain induced suppression of the Curie temperature with decreasing film thickness is ruled out since all the films exhibit a constant out of plane tensile strain (0.5%) irrespective of their thickness. The coercivity of the films is observed to be an order of magnitude higher than that of the bulk. This is attributed to the local variation of the internal strain that introduces strong pinning sites (via. magnetoelastic interaction) for the magnetization reversal. In addition, an increase in the electrical resistivity and coercivity is observed with decrease in film thickness and it is strongly believed to be due to the interface effect.

**Chapter 5** reports on the investigation of the effect of ferromagnetic layer on (i) pair breaking effect and (ii) vortex dynamics in different superconducting(S)/ ferromagnetic (F) bi-layers grown by pulsed laser deposition. The current (I) dependent electrical transport studies in the S/F bi-layers exhibit a significant reduction in the superconducting transition temperature with the increase in applied current as compared to single $YBa_2Cu_3O_7-\delta$ layer and it follows $I^{2/3}$ dependence in accordance with the pair breaking effect. Moreover, the superconducting transition temperature in $YBa_2Cu_3O_7-\delta/ La_{0.7}Sr_{0.3}MnO_3$ bilayer is surprisingly found to be much larger than the $YBa_2Cu_3O_7-\delta/ La_{0.5}Sr_{0.5}CoO_3$. It appears that the current driven from a material with low spin polarization (-11%) like $La_{0.5}Sr_{0.5}CoO_3$ can also suppress the superconductivity to a larger extent. This indicates that the degree of spin polarization of the ferromagnetic electrode is not the only criteria to determine the suppression of superconductivity by pair breaking effect in superconductor/ferromagnet hybrid structures; rather the transparency of the interface for the spin polarization, the formation of vortex state
due to the stray field of ferromagnetic layer and the ferromagnetic domain patterns might play significant roles to determine such effect. More interestingly, the spin diffusion length in \( \text{YBa}_2\text{Cu}_3\text{O}_7-\delta \) is found have a much longer length scale than that reported earlier in the study of F/S heterostructures. The activation energy \((U)\) for the vortex motion in S/F bilayers is reduced remarkably by the presence of the F layers. In addition, the \( U \) exhibits a logarithmic dependence on the applied magnetic field in the S/F bilayers suggesting the existence of decoupled 2D pancake vortices. This result is discussed in terms of the reduction in the effective S layer thickness and the weakening of the S coherence length due to the presence of F layers.

**Chapter 6** deals with the magnetotransport study on two different kind of F/S/F trilayers viz. \( \text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3/\text{YBa}_2\text{Cu}_3\text{O}_7-\delta/\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3 \) and \( \text{La}_{0.5}\text{Sr}_{0.5}\text{CoO}_3/\text{YBa}_2\text{Cu}_3\text{O}_7-\delta/\text{La}_{0.7}\text{Ca}_{0.3}\text{MnO}_3 \) with changes in superconducting and ferromagnetic layer thickness. The activation energy for the vortex motion in F/S/F trilayer is found to decrease considerably as compared to S/F bilayer and it also exhibits a logarithmic dependence on magnetic field which gives the signature of existence of decoupled 2D pancake vortices. The magnetotransport study reveals that a much lower magnetic field is required to suppress the superconductivity in trilayer as compared to single YBCO layer. Moreover, the transport study also reveals that a threshold thickness of YBCO is required for the onset of superconductivity in trilayer structure and the onset of superconducting \( T_c \) increases with increase in YBCO thickness. More strikingly, a remarkable unconventional anisotropic superconducting \( T_c (T_c\|c\text{-axis}<T_c\perp c\text{-axis}) \) is observed in \( \text{La}_{0.5}\text{Sr}_{0.5}\text{CoO}_3/\text{YBa}_2\text{Cu}_3\text{O}_7-\delta/\text{La}_{0.7}\text{Ca}_{0.3}\text{MnO}_3 \) trilayer for the magnetic field applied parallel and perpendicular to \( c\)-axis. The trilayer system also exhibits a huge positive magnetoresistance (MR) below superconducting \( T_c \) and it could arise due to vortex dissipation in liquid state of superconductor in the tri-layer structure.

Finally, the thesis concludes with a general conclusion and an outlook in this area of research.