CHAPTER 1: INTRODUCTION

“Disability need not be an obstacle to success. I have had motor neurone disease for practically all my adult life. Yet it has not prevented me from having a prominent career in astrophysics and a happy family life. But I realize that I am very lucky, in many ways. My success in theoretical physics has ensured that I am supported to live a worthwhile life. It is very clear that the majority of people with disabilities in the world have an extremely difficult time with everyday survival, let alone productive employment and personal fulfilment.”

-Prof. Stephen W Hawking

The above words of professor Stephen Hawking have been quoted from the foreword that he wrote for the first world report on disability [1] jointly published by the World Health Organisation (WHO) and the World Bank in 2011. His statement is very true as the persons with disability (PWD) find it difficult to live without support to meet their daily basic needs. Hence, this work focuses on enhancing the quality of life of wheelchair users, a major section of the population of PWD.

As per the world report on disability, more than one billion people live with some sort of disabilities which constitutes to about 15% of the world’s population, which is higher than the previous WHO estimation of 10% in 1970 [1]. Out of which 70 million people are movement disabled and require a wheelchair for locomotion. The report also specifies that the rate of disability is raising drastically, mainly because the populations are ageing, as a result of increased occurrences of accidents and due to increase in chronic health conditions, among the other causes. In India as per the 2011 census data, 26.81 million people are disabled and this constitutes to 2.21% of the total Indian population, out of which 20.28% are movement disabled people [2]. While these official estimates of disability are very low, the World Bank in 2009 reported a higher incidence of disability of at least 5-8% in India [3]. Citing 2002 national sample survey (NSS), the same report points out that there are 10.6 million people with movement disabilities which constitutes to 57.5% of PWDs. The large
difference in official estimates and that of the World Bank estimates is due to several reasons like, exclusion of certain disability categories in official estimates, differences in method of questioning on disability mainly because of employing untrained interviewers, social stigma attached to disability, etc [3].

Another important fact put forward by the world report on disability is that, there is a higher risk of disability in older ages [1] and various studies show that the world population is ageing at unprecedented rates. As per youth data sheet published by Population Reference Bureau in 2013, the population of youth of age group between 10 and 24 around the world is 1,809.6 million, which constitutes to 25% of the total population [4]. The figures provided imply that by 2050, the ‘older population’ would comprise 27% of total world population. A study by United Nations- Department of Economics and Social Affairs points out that in 2011, there were approximately 647 million people in the world who come under ‘older people’ category and this figure is expected to accelerate to 2 billion by 2050 [5,6]. A report jointly brought out by United Nations Population Fund and Help Age International says that India has 100 million elderly people at present which constitutes to 7.2% of total world population and the number is expected to increase to 323 million constituting to about 20% of total population, by 2050 [7].

Assistive technologies can be powerful tools to increase independence of PWD, by reducing the intensity of disability on one hand and reducing the cost of ‘care’ on the other [1]. The lack of assistive devices makes the PWD to depend on family members and this affects social and economical life of both the disabled person and the family members. In developing countries, only 5-15% of population who require assistive
devices have access to them [8]. Moreover the quality of the assistive devices available in these countries is not comparable with that in developed countries.

Joseph F. Engelberger, the father of robotics and the man behind the first industrial robot, in an interview given to Businessweek in 2003 said that an elder care assistive robot can be developed at a cost of less than $700,000 using the then current technologies [9]. He also opined that the robot can be rented for $600 per month and operated at a cost of $1.25 per hour, resulting in a cost effective eldercare solution compared to healthcare home workers costing around $15 per hour. The eldercare robot that Engelberger visualized was a multipurpose one, for which he wanted to have technical partnerships with industrial giants in healthcare products apart from financial investment. Engelberger’s vision is not yet realised, as researchers are working on various eldercare robots in labs around the world. These products are emerging very slowly and they do not address all the issues concerned.

Mobility is a fundamental aspect of health which leads to social integration and individual well-being. Mobility of certain temporarily disabled wheelchair users can be regained by rehabilitation processes and they can be successfully re-integrated into a productive and active life. But most of the lower limb disabled people and aged persons with lower limb incapability depend on wheelchairs for their mobility, for the entire life [10]. For them, independent mobility increases their self confidence, self esteem and happiness levels due to self reliance. Therefore, the role of value added assistive systems takes an important place in improving the quality of their life.

Reduced mobility affects many other factors in daily life of the target population under consideration. Pain, muscle weakness, osteoporosis, practical loss of motion or physical deformity of joint structure, etc. may restrict an aged person from walking.
Another area of focus is the difficulty when rising to a standing position, as rising from a chair is a common but demanding activity involved in day-to-day life. The practical difficulty in walking and rising from sitting position affects many daily life activities including accessing toilet. Either a caregiver’s assistance may be required for the disabled person to use the toilet which affects one’s dignity [11], or he/she may have to struggle to transfer onto the toilet commode. In public places, like government offices, cinema halls, railway stations, bus stations, etc., where wheelchairs are not available, the disabled people are left with no option but to crawl from their vehicle which is usually a customized three or four wheeled scooter, to their destination. Navigating by crawling on floor causes mental agony to them and also hurts any sane and humane on-looker. Thus, it is essential to develop devices that would assist PWD to transfer themselves from one surface to another so as to achieve independent living and to keep up their self esteem.

1.1. ORGANISATION OF THE THESIS
Chapter 2 covers literature survey on existing assistive devices and status of relevant research works in the area of development of self-transfer devices. It gives an overview on various mobility assistive devices including manual wheelchairs and powered wheelchairs. Further, it provides information on few caregiver assisted lift or transfer devices that are commercially available and that are being used in health care facilities widely. Details on researches happening in the field of transfer devices with an emphasis on self-transfer devices are also covered in this chapter.

Chapter 3 deals with the conceptual design of the proposed self-transfer devices which involves decisions related to the transfer process, the intermediate stages and the mode of achieving the required motions. The chapter also discusses target users,
design criteria, target specifications and the concept development process. Further, it explains the transfer process designed for the operation of the proposed devices.

Knowledge of mass moment of inertia of human body and its segments are necessary for various problems in biomechanics and its applications. Chapter 4 focuses on the estimation of moment of inertia of a human body when bending forward, which is needed for determining the torque required to rotate the turntable of the proposed device. This chapter also covers a brief review on studies of different anthropometric data like mass of the body segments, centre of mass, radius of gyration, etc. Using these data and certain assumptions, mass moment of inertia of human body bending forward is estimated by applying laws of basic mechanics. Towards the end of the chapter, verification of the estimated value using a CAD software is presented.

Chapter 5 discusses the design and development of the proposed novel and frugal manual self-transfer device. The detailed design includes torque and force estimation for the selection of actuators, complete component and assembly design and fabrication thereafter. This chapter also covers details of trials carried out to optimize the ergonomic aspects of the design.

Chapter 6 concentrates on design and development of the powered version. Apart from the detailed design, which is similar to that of the detailed design of the manual version, details of the electrical design and development of a control system with safety interlock are also covered in this chapter.

Chapter 7 covers the details of the trials conducted using both manual and powered self-transfer devices involving potential beneficiaries for the purpose of testing and validating the devices. Further, the performance of the developed powered self-
transfer device is compared with the existing devices in terms of comfort and operation.

Finally chapter 8, summarizes the whole work highlighting the contributions made to the scientific scenario and social scenario.