**Collaborative Robot Safety Design and Development**

The course is provided by University at Buffalo. In the first week we gain knowledge on the classification of robots used in industries. Early robots worked in factories performing heavy and dangerous jobs, such as welding palletizing. Smaller robots emerged for use in assembly and packaging applications. Soon robots began being used for non-factory applications. Since then, there was great development in robots. These days robots are designed such that they can be hand guided. Service robots are also being developed which are humanoids. These have applications such as fruit picking and for surgical applications. Collaborative robots are robots that interact with people, therefore there is a demand for safety. There are many safety standards in place that are put in place to ensure safety of the users. We then go on to learn the concept of controlled reliability. There are three operations of robots, they are, coexistence, cooperation, and collaboration. The course also deals with a few safety standards in industries. The steps for risk assessment are to define the use of the collaborative robot and to identify the different tasks identified with the operator and the hazard associated with these tasks. Decision matrices are also used to carry out risk assessment.

A robot safety incident can occur for a variety of reasons. First, a robotic arm or equipment can cause an accident, Second, a mechanical part fails in the robot system. Lastly, there could be an uncontrolled power supply to the robot. Collision, trapping are some incidents that take place during accidents. Workspaces are designed keeping in mind the safety of the workers, sensors are used to detect the proximity of the robot to the person. The sensors are fitted in specific positions based on the application of the robot. The robots must also take human errors and sensors into account for optimal safety.

Robots that have large mass and velocity will have large impact on collision. The factors that affect the impact during collision are motor torque, kinetic energy, and distance to decelerate. Air bags are added to robots to reduce impact. Collaborative robots can bump into people and continue performing their task without injuring the person. Moving mass of the robot and effector must be minimised by selecting appropriately sized robots. Collaborative robots are quickly gaining acceptance in several different industries. They are reducing the cost and risk of installing robots. The University of Mainz, in Germany developed several key measures for a machine that could apply both static and dynamic collision forces to various parts of the human body.

1. Clamping Force for static conditions

2. Impact Force for dynamic collisions

3. Pressure for the force per unit area

4. Compression Constant for the stiffness of different regions of the body