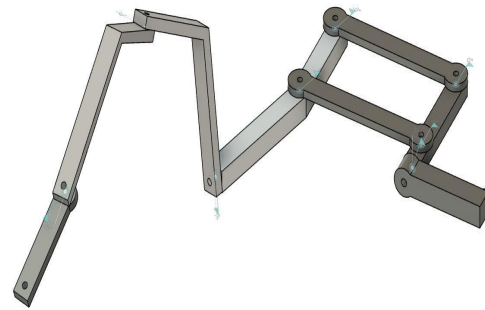
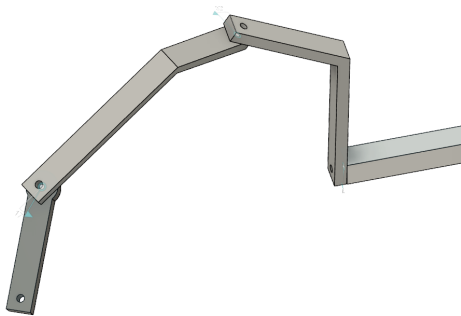


The harmony exoskeleton should coordinate with the natural motion of the shoulder. The exoskeleton is to be worn around the upper body, which controls and coordinates with a wide range of motion of the shoulder and upper arm without much resistance to the user's natural movement. For this purpose, the exoskeleton needs to coordinate with the mobility of the shoulder girdle, which includes elevation-depression and protraction-retraction, and coordinate with the glenohumeral (GH) joint, which is a ball and socket joint. This shoulder joint, in total, has 5 degrees of freedom.



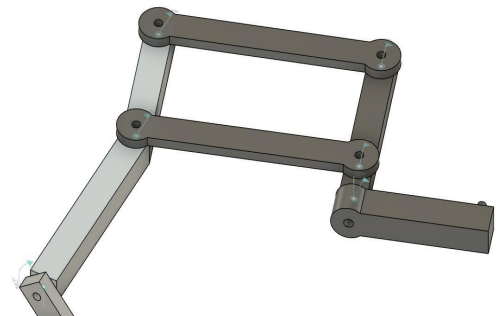
**Fig 1: Shoulder Joint with Five degrees of freedom**



The ball and socket motion of the glenohumeral (GH) joint is provided by a kinematically equivalent mechanism that goes around the shoulder in which three links are placed in a serial chain connected through revolute joints whose axes intersect at a point. This provides 3 degrees of freedom to the motion.

**Fig 2 : Three links (3 DOF)**

Now, the GH joint can have translation motion such as elevation-depression and protraction-retraction through the shoulder girdle represented by SHR. During translation, the center of rotation of the ball and socket equivalent of the three-chain mechanism should follow the GH joint of the user's shoulder. Experimental results showed that the trajectory of the GH joint follows circular arcs. Therefore, the elevation-depression and protraction-retraction can be provided by a link pivoted at the COR of the circular arcs. So, the shoulder girdle mechanism consists of a revolute joint that provides elevation depression and a parallelogram to provide protraction-retraction. This provides an additional 2 degrees of freedom.



**Fig 3: Parallelogram (2 DOF)**