BELL CRANK DESIGN

I) BACKGROUND

This design exercise deals with the tradeoff between strength and weight. This tradeoff is most acute in the aerospace industry, especially in glider design. In an unpowered glider, weight is at a very high premium since there is no engine to propel the craft forward and create a lift.

For those unfamiliar with the operations of a glider, a glider is towed into flight by a powered airplane and then released. The glider pilot maintains flight by seeking the lift generated by upward thermals (air rising due to ground surface heating).

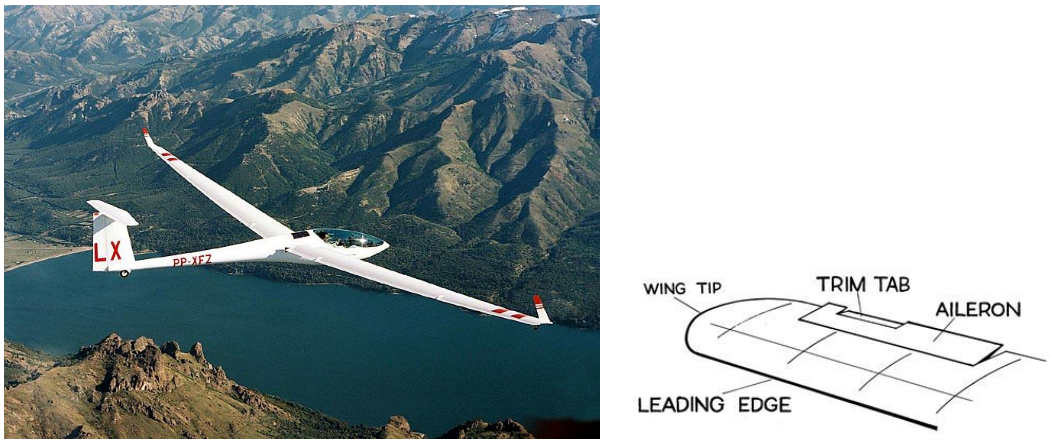


Figure I-1: Glider and aileron illustration

The ailerons in a plane, shown in Figure I-1and I-2, are stabilizing surfaces in the wings that the pilot can use to level the plane in flight. They are also used in conjunction with other control surfaces to change the heading of an airplane. By moving the stick side to side, the pilot will cause the aileron on both wings to activate in the opposite direction, thus creating an upward force on one and simultaneously creating a downward force on the other. The resulting motion is referred to as a roll.

The aileron control system in a glider is very simple and consists of a combination of wires and/or rods that directly connect the stick (what the pilot holds in hand) to the ailerons. A schematic of the aileron control system is shown in Figure I-2. A critical component of that system is a mechanism known as a bellcrank. A bellcrank transfers motion from one direction to another (generally 90°).

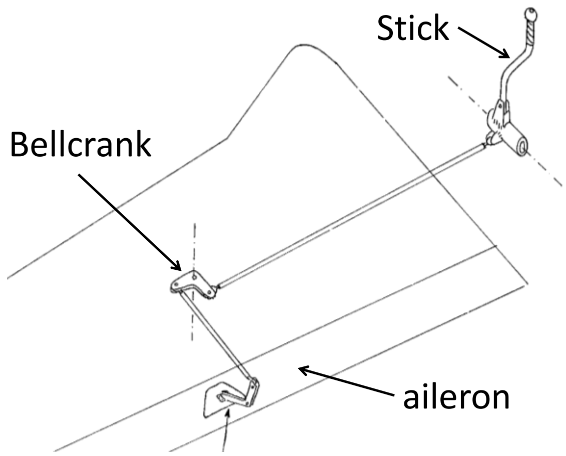


Figure I-2: Aileron control system showing a bellcrank linkage

II) DESIGN PROBLEM

Design a bellcrank for a glider aileron control system that is light and strong. Depending on your teacher's instructions, you may be required to design, prototype, assemble, and test your design. If your institution has a rapid prototype machine, your prototype can be assembled with the bearing, ball joint, and spring, and then tested, in tension, to failure and compared to the rest of the class. The "winning" design will be the bellcrank with the highest failure load to weight ratio.

III) DESIGN SPECIFICATIONS AND CRITERIA

Figure III-1 shows a production bellcrank with a bearing and four holes where ball joint bearings can be connected. Please note that the bellcrank shown in Figure III-1 is only for reference. Your design will require design features aimed at reducing weight such as tapering the width and removing material wherever is possible.

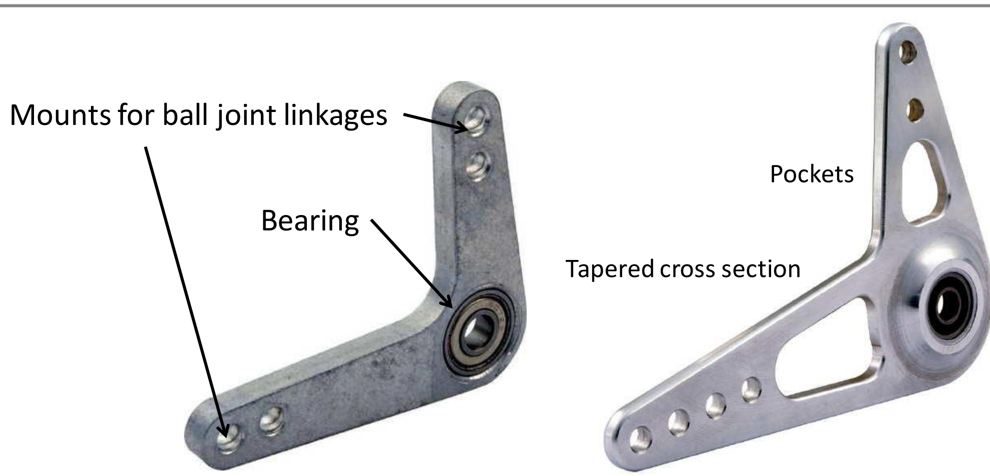


Figure III-1: A production bell crank

The bellcrank that you design will need to fit the exact ball bearing, ball joint linkages, and spring shown in the supporting information. Figure III-2 shows details of the exact positioning of the components. The bell crank shown in III-2 is basically symmetric.

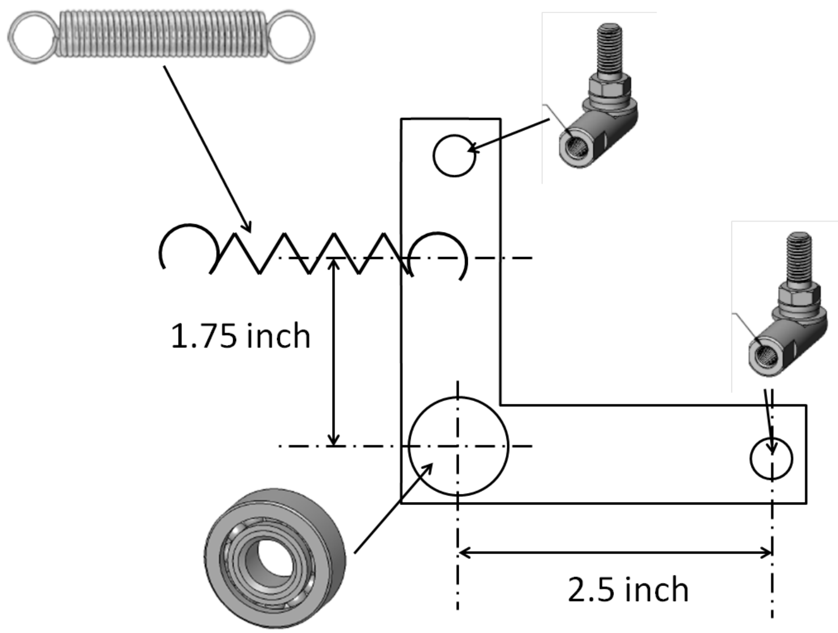


Figure III-2: Positioning of related parts

To insure the minimum required strength of the bellcrank, there should be a minimal wall thickness at any pocket or cutout (i.e. $(h-d)/2$) of at least 0.125 inch. The material thickness w at the ball joint should be at least 0.25 inch and no more than 7/16 inch. Also, the thickness at the location of the bearing needs to be thick enough so that the bearing does not hang over.

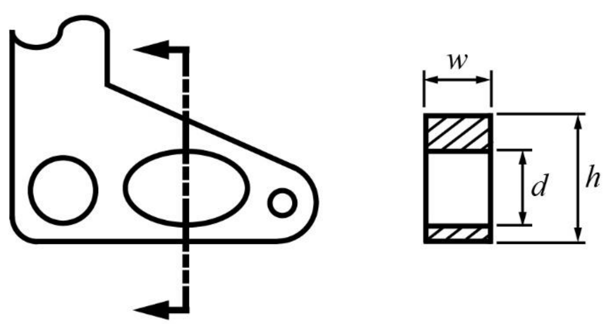
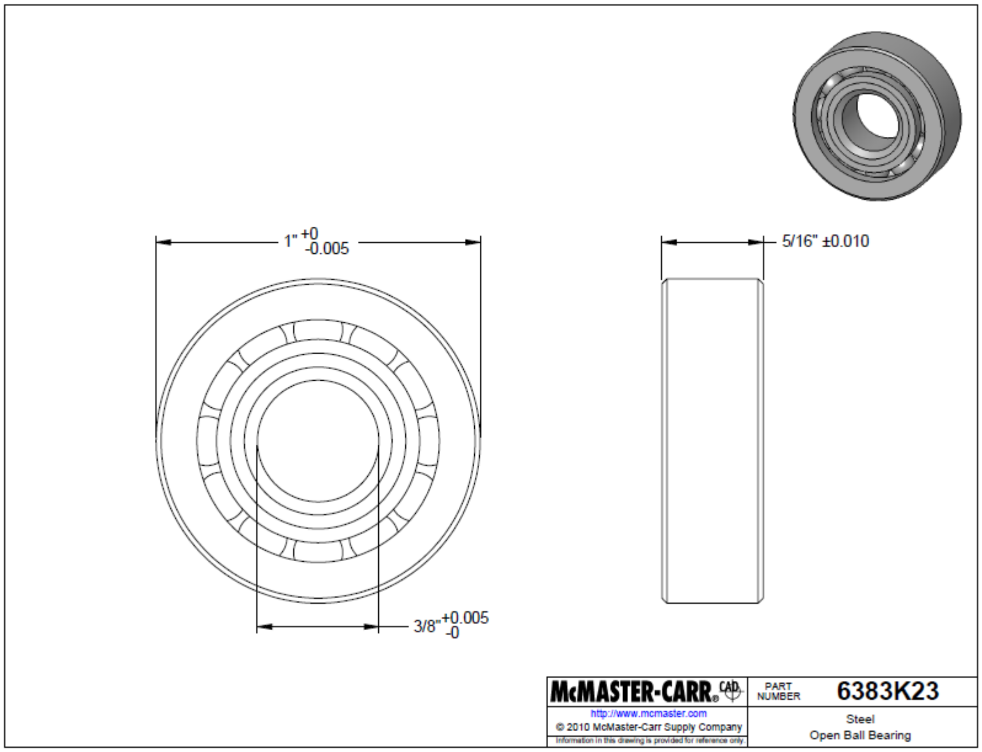
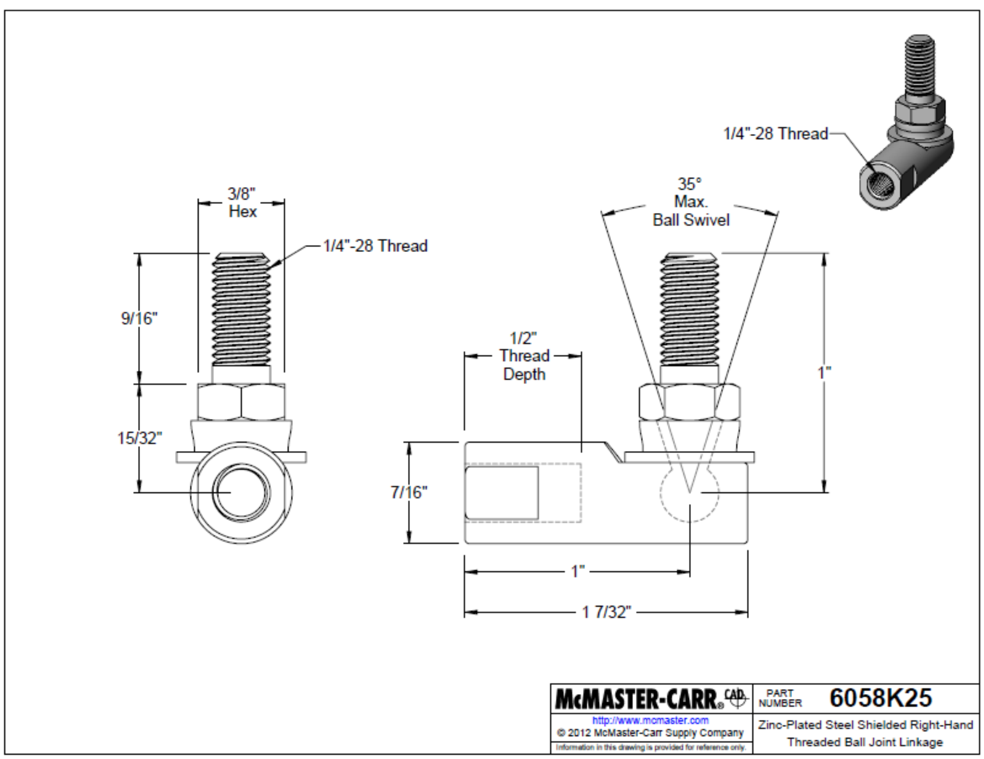


Figure III-3: Cross sectional area of a pocket

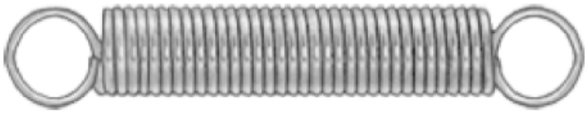
IV) SUPPORTING INFORMATION





Type 302 Stainless Steel Extension Spring

6.0" Length, .500" OD, .063" Wire Diameter



With Loop Ends

In stock
$6.35 per pack of 1
94135K36

Spring OD	0.5"
Wire Diameter	0.063"
Extended Length	10.52"
Load, lbs.	
Minimum	3.84
Maximum	16.7
Rate, lbs./inch	2.84
Additional Specifications	With Loop Ends
	6" Overall Length