1. Initial FRDPARRC Table

Functional Requirements	Design Parameters	Analysis	References	Risks	Counter-measures
Holding strength (torque) amplification	The length of handle should be longer than the gripping tips (as measured from the pivot point)	basic lever laws, combined with realistic size expectations for gripping pliers like those chosen for this exercise	Experience with pliers (particularly slip-joint pliers, which are basically identical in form to the basic pliers chosen for this exercise (except with a fixed joint))	A customer will need to apply more force than they can reasonably apply with the chosen plier dimensions	Refer customer to other types of pliers that can provide more force or provide a more efficient way of gripping the object in question (i.e. switching to a pipe wrench when tightening iron pipe)
Easy to hold	The handles should be of a size that is compatible with standard human hands and may have some sort of rubber or plastic material providing cushioning and/or a non-slip surface.	If customers are going to use these pliers for an extended period of time, or to apply some serious force, having a comfortable, ergonomically correct design is important	Most all pliers today have handles that are somewhat rounded and have some degree of cushioning	What's comfortable for one person may not be good for another	Have several potential designs and do some quick consumer testing
Extra grip on tips	Serrations or teeth on the tips to better grab bolts, fasteners, or whatever else the pliers are being used on	A serrated gripping surface makes it harder for the tips of the pliers to slide off of the part being gripped (increases friction between the two). Appropriately sized serrations can also help the pliers grab onto geometric features that may exist on the target part (like the edges of a hex bolt)	Experience with pliers made for gripping objects	Inappropriately sized or spaced serrations	Have multiple differing sections, or identify a particular type of application for the pliers and make the grip "serrations" fit that application
Strong enough to avoid deformation	Since we want the pliers to last a long time, and much of the use of these pliers will be to grab things like fasteners which are typically made of harder materials like steel and stainless steel, the pliers should be made of a suitably hard material, like an alloy steel or tool steel.	Considering what you'll be grabbing with the pliers, and what that stuff is made of.	McMaster-Carr information on fastener materials and general observation of material composition of existing pliers	Unless people are really abusing these pliers, not a whole lot of risk in choosing a strong alloy steel for the pliers. Perhaps an increase in cost over weaker steel.	Offer multiple quality ("performance") levels, or use your high quality as an advertising point justifying the cost
Reasonably priced	~$10-15	If you want to sell a lot of pliers, they have to be reasonably priced	Amazon and Home Depot pricing for pliers	People can just buy cheap Harbor Freight pliers	Offer multiple quality ("performance") levels, or use your high quality as an advertising point justifying the cost

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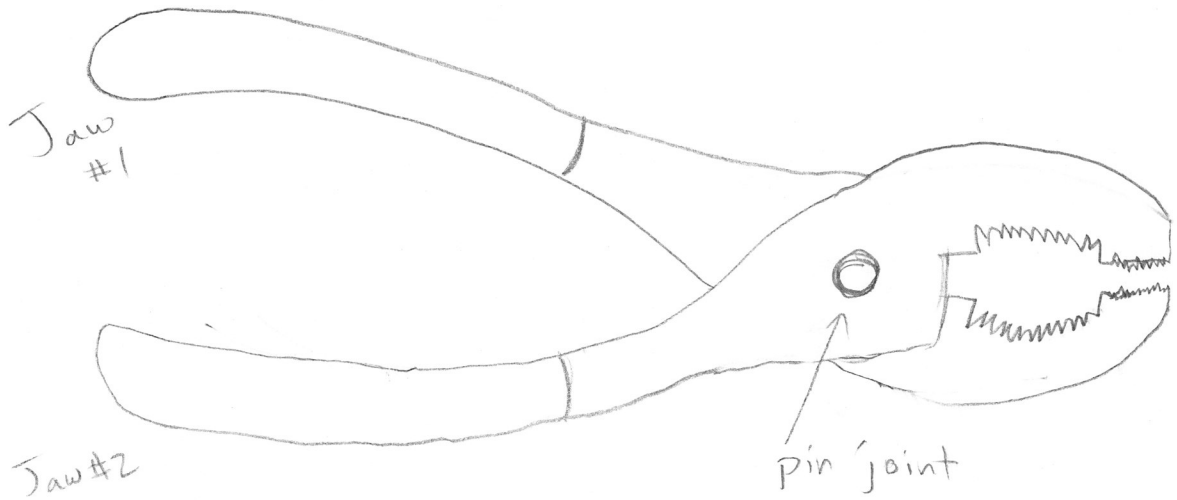
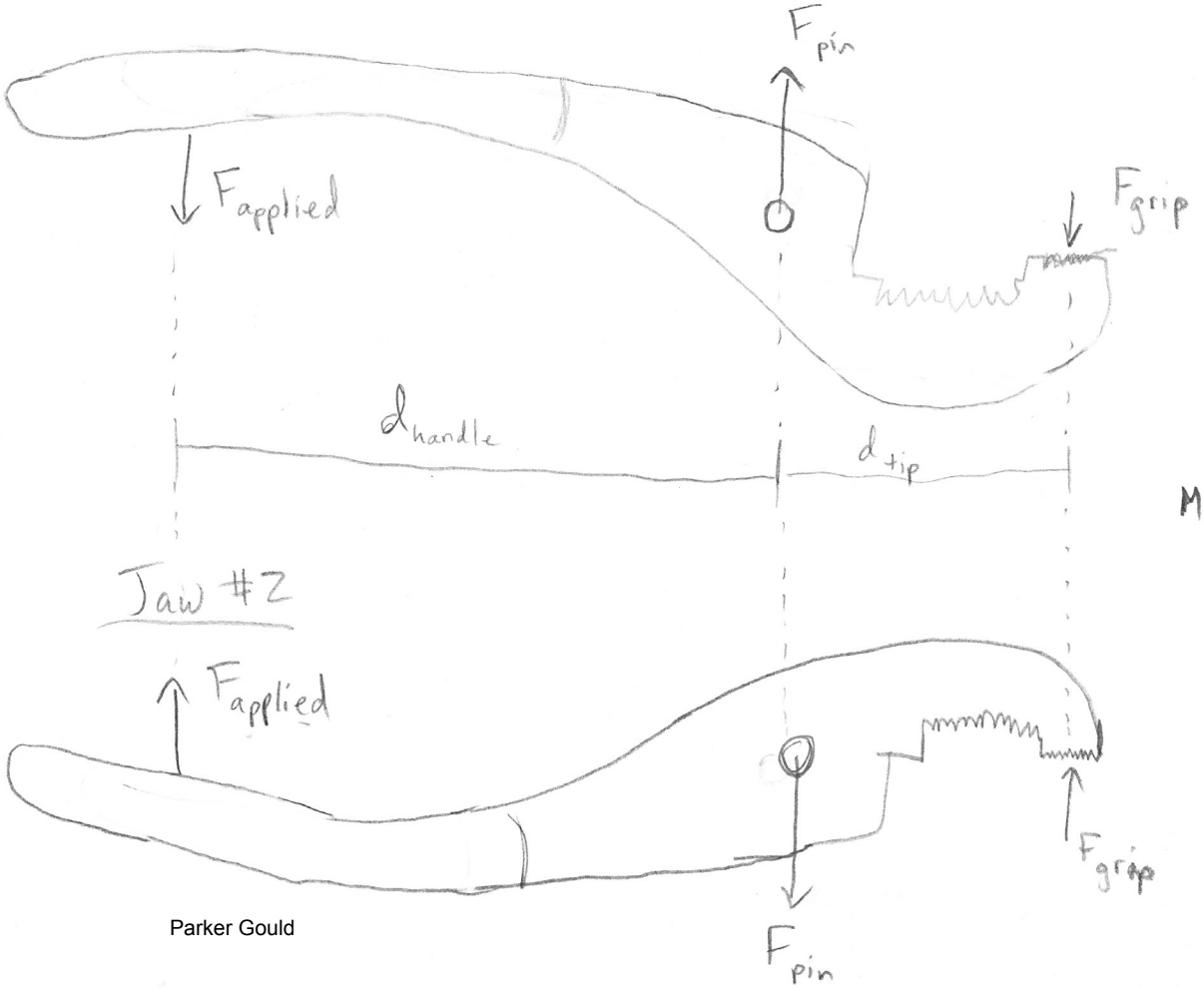
2. Stick figure pliers sketch

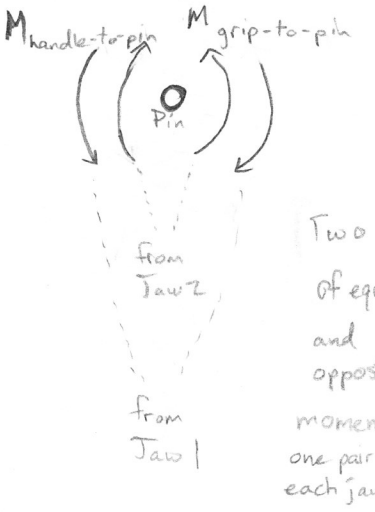


3. Free Body Diagrams

Jaw #1



Pin Joint



Two pairs of equal and opposing moments, one pair from each jaw

4. Equations and Words

Jaw #1 and #2

$$F_{applied} + F_{grip} - F_{pin} = 0$$

Pin Joint

$$M_{handle\text{-}to\text{-}pin} - M_{grip\text{-}to\text{-}pin} = 0$$

$$(F_{applied})(d_{handle}) - (F_{grip})(d_{tip}) = 0$$

$$(F_{applied})\left(\frac{d_{handle}}{d_{tip}}\right) = F_{grip}$$

The equations from the free body diagrams tell us that to achieve an appropriate amplification in grip force, the length from the handle to the pin joint must be longer than the length from the pin joint to the grip point (d_{tip}). The bigger the ratio, the more force amplification you'll get for a given input force (squeezing the handles). This is the basic lever law.

The second thing the equations give us are some reference points for how strong our components need to be. For a given set of dimensions (d_{handle} and d_{tip}) and a given squeezing force ($F_{applied}$), we can determine the resulting grip force (F_{grip}) and the counteracting pin joint force (F_{pin}). With numbers for these forces, we can make appropriate material and dimensional (e.g. thickness) design decisions.

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5. For the standard rivet-style pin joint that connects the two handles of the pliers, there is a shear force on the pin joint as the pliers are closed. Over heavy use, this rivet may become deformed, which will affect the alignment of the two plier jaws. This would be a much bigger deal on cutting pliers (as opposed to gripping pliers like those being discussed here). To make the joint last longer you could switch to a box-style pin joint, where one handle of the pliers has a hollow area that the other handle slides through (I've seen this mostly on channel-lock pliers). With this style of interface, the shear force on the pin/rivet is better distributed. Box-style joints are a lot more complicated to make though. A potentially cheaper option would be to switch to a really well designed screw joint (like a rivet, but with two parts, a male screw and female nut). This way you could just replace a loose joint with a fresh one as needed.

6. As alluded to in the above answer, a loose pin joint between the two plier jaws would cause a tip misalignment (I believe this is a parasitic error). Any misalignment would very likely get worse under load, as the forces would likely cause the spatial deviation (i.e. misalignment) between the two jaws to be maximized. Of course general sloppiness in the fabrication process (machining / forging / casting / etc.) could lead to plier jaws that don't line up, even if the pin joint is perfectly rigid and aligned.

7. Updated FRDPARRC Table

Functional Requirements	Design Parameters	Analysis	References	Risks	Counter-measures
Holding strength (torque) amplification	The length of handle should be longer than the gripping tips (as measured from the pivot point)	basic lever laws, combined with realistic size expectations for gripping pliers like those chosen for this exercise	Experience with pliers (particularly slip-joint pliers, which are basically identical in form to the basic pliers chosen for this exercise (except with a fixed joint))	A customer will need to apply more force than they can reasonably apply with the chosen plier dimensions	Refer customer to other types of pliers that can provide more force or provide a more efficient way of gripping the object in question (i.e. switching to a pipe wrench when tightening iron pipe)
Easy to hold	The handles should be of a size that is compatible with standard human hands and may have some sort of rubber or plastic material providing cushioning and/or a non-slip surface.	If customers are going to use these pliers for an extended period of time, or to apply some serious force, having a comfortable, ergonomically correct design is important	Most all pliers today have handles that are somewhat rounded and have some degree of cushioning	What's comfortable for one person may not be good for another	Have several potential designs and do some quick consumer testing
Extra grip on tips	Serrations or teeth on the tips to better grab bolts, fasteners, or whatever else the pliers are being used on	A serrated gripping surface makes it harder for the tips of the pliers to slide off of the part being gripped (increases friction between the two). Appropriately sized serrations can also help the pliers grab onto geometric features that may exist on the target part (like the edges of a hex bolt)	Experience with pliers made for gripping objects	Inappropriately sized or spaced serrations	Have multiple differing sections, or identify a particular type of application for the pliers and make the grip "serrations" fit that application
Strong enough to avoid deformation	Since we want the pliers to last a long time, and much of the use of these pliers will be to grab things like fasteners which are typically made of harder materials like steel and stainless steel, the pliers should be made of a suitably hard material, like an alloy steel or tool steel. Could also specifically harden the teeth to a higher level than the rest of the pliers to increase their durability.	Considering what you'll be grabbing with the pliers, and what that stuff is made of.	McMaster-Carr information on fastener materials and general observation of material composition of existing pliers	Unless people are really abusing these pliers, not a whole lot of risk in choosing a strong alloy steel for the pliers. Perhaps an increase in cost over weaker steel. Some customers may prefer softer jaws to avoid marring or deforming what they're grabbing.	Offer multiple quality ("performance") levels, or use your high quality as an advertising point justifying the cost. The best way to address a softer jaw desire would probably be to have a separate model with soft jaws, but another option might be some sort of cover or insert (like people sometimes use o vise jaws) made of a softer material that goes over the standard jaw.
Reasonably priced	~$10-15	If you want to sell a lot of pliers, they have to be reasonably priced	Amazon and Home Depot pricing for pliers	People can just buy cheap Harbor Freight pliers	Offer multiple quality ("performance") levels, or use your high quality as an advertising point justifying the cost
Reliable open and closing motion	A very well designed pin joint that will not degrade / loosen / wear out over time or extended use.	Some of the highest end gripping pliers on the market use either a standard rivet joint or a screw-type rivet joint. This suggests that this is probably sufficient, and a box joint is unnecessarily expensive/complicated.	Knipex, NWS, Lindstrom	A shoddy joint will ultimately lead to shoddy pliers, which will be bad for business	Rigorously test the type of joint selected to make sure it will stand up to plenty of wear and tear.