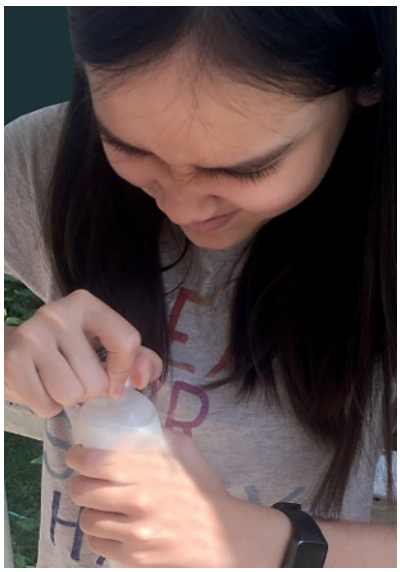
Torque

Shannon and Ian Jacobs

A common vexing problem: I can't open a bottle with a screw top.



I can't break the tags between the collar and the cap. I could get a knife and cut around the cap to separate the collar, but I've seen a cloth put over a cap to make it easier to break the seal.

Everyone I ask says that putting the cloth over the cap improves the grip. I tried that myself, but the cloth slipped more than my fingers. There was less friction. I still couldn't open it.

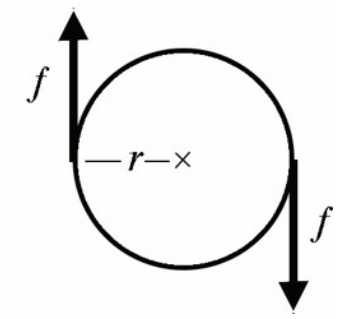
I asked Dad. He said I needed more "*talk*". I said. "I talk a lot: how would that help!?" … and he said … "No-no. I mean "***talk***". "Let me write it."

TORQUE

"*That's not good: misunderstandings like that start wars.*"

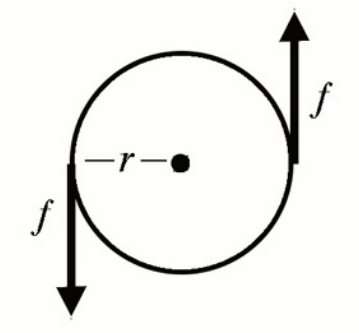
Torque is the clockwise turning effect of two equal and opposite forces, ***f*** *and* ***-f****,* a distance 2*r* apart.

Torque *T* is defined as 2*f* times *r.*

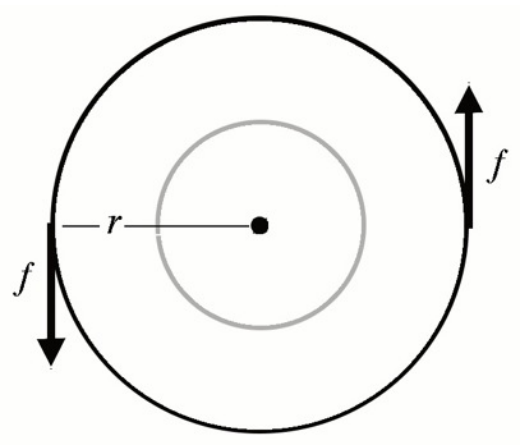


The torque would be larger if the forces ***f*** *and* ***-f*** are increased, *which I can't make happen,* or the two forces could be moved further apart. That could be done by increasing the effective radius of the cap.

My two attempts to unscrew the cap



$T = 2fr$

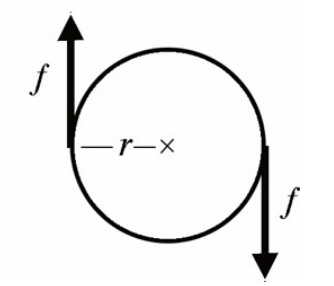


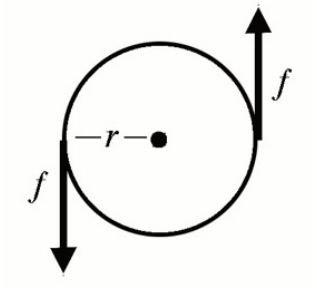
$T = 4fr$

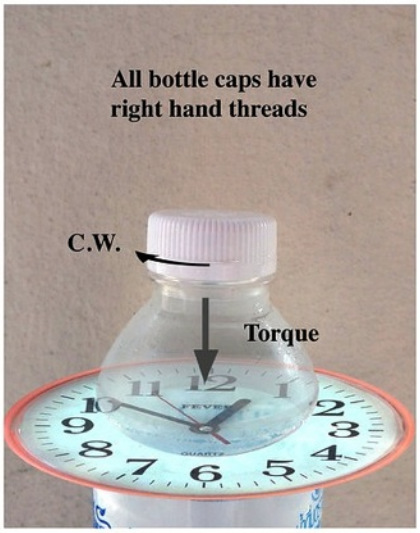
Using the pad doubles the torque I can apply with the same forces. I can now unscrew the cap.

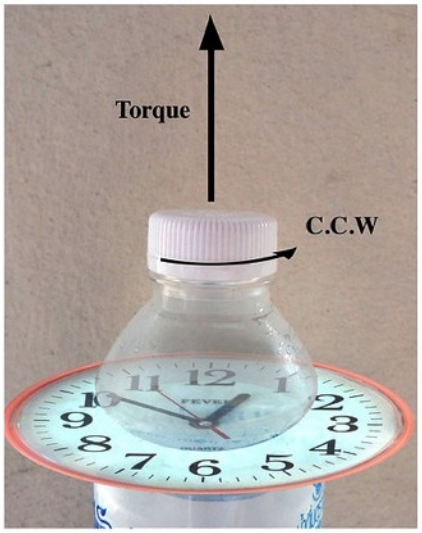
Putting the Brillo pad rubber side down grips the cap almost as well as skin. (Wetting it a little may help if it slips.)

In torque diagrams the centre is marked with a cross when rotation is clockwise and with a large dot when rotation is counter-clockwise.









The cap is tightened by turning it clockwise (left).

> The torque applied to tighten the cap is defined as an axial arrow of length $2fr$ into the bottle. The forces f and $-f$ are small until the cap becomes tight. *The cross in the diagram above the image represents the tail feathers of the torque arrow.*

The cap is unscrewed by turning it counter-clockwise (right).

> The torque applied to unscrew the cap is defined as an axial arrow of length $2fr$ into the room. Forces f and $-f$ are large to break the seal and then may be small. *The dot in the figure above the image represents the tip of the torque arrow.*

These torque directions apply to bottle caps and nuts for all normal bottles and bolts that are made with right-hand threads. For a left-hand thread see *Spirals* in the Mathematics index.