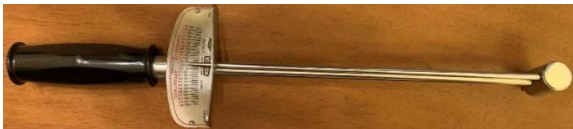# A Torque Wrench to Adjustable Wrench Adapter, Version 2.3

By R. G. Sparber

Protected by Creative Commons.[1]

The Problem

Once in a while, I have a fastener I need to torque, with a head that doesn't match any of my sockets. There are also times when a socket cannot be used due to a lack of clearance above the head. However, an adjustable wrench fits.

Why not join the adjustable wrench to the torque wrench?

Conclusion

I built an adapter that permits an adjustable wrench to be connected to a torque wrench. A multiplier is used to translate the indicated torque to the actual torque.

This multiplier can be calculated using the length of the torque and adjustable wrenches.

It can also be calculated by measuring two torques and dividing one into the other. This method takes into account your actual geometry.

Contents

The Equation

Before cutting any metal, I had to convince myself that this arrangement would give valid results. After a false start, I was given two web sites that presented the solution. The first one came from Dave Kellogg and the second one came from John Cooper. I was also given a video by Gadgeteer on homemadetools.net.

These sources present the same equation for the case of the adjustable wrench aligned with the torque wrench. None derived the equation. I wanted to understand the underlying logic, so I took on the challenge.

What is going on?
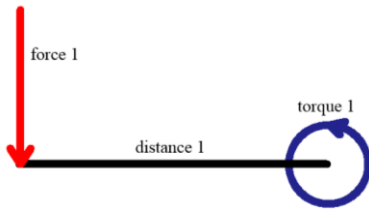
Torque, as the units tell us, is a force acting at a distance: force times distance[2]. That is why we have foot-pounds, inch-pounds, and centimeter-kilograms. I apply **force 1** at **distance 1** from the square drive, and I get torque T_1.

As an equation, we have

$$T_1 = F_1 \times D_1 \quad (1)$$

Where T_1 is torque 1, F_1 is force 1, and D_1 is distance 1. The force must be perpendicular to the distance for this equation to be true.

I can solve for force 1:

$$F_1 = \frac{T_{indicated}}{D_1} \quad (2)$$

Where $T_{indicated}$ is what you see on the scale.

My torque wrench is an ingenious device. As I apply a force to the handle, there is a small pin (yellow arrow) inside that connects to a bar. As long as the handle does not touch the bar, the force is applied through this pin. At the other end of the torque wrench is my square drive. Distance 1 is from the center of the square drive (red arrow) to the pin. In my case, that is 13.7-inches.

As I apply a force to the handle with the square drive coupled to a fastener, it slightly bends the bar. An indicator rod, attached only to the square drive end, does not bend. The amount of bending of the bar is therefore measured on the scale and calibrated to read out in inch-pounds.
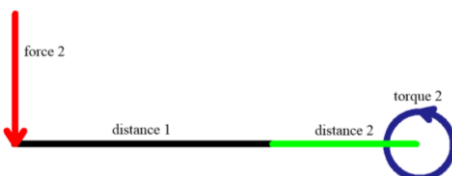
When I add my adjustable wrench (green line), the distance from the pivot pin to center of the fastener increases by **distance 2**. I again have a force acting at a distance:

$$T_2 = F_2 \times (D_1 + D_2) \quad (3)$$

---

[2] It is essential that the force is perpendicular to the distance line.

Where T_2 is torque 2, F_2 is force 2, D_1 is distance 1, and D_2 is distance 2. From equation (2),

$$F_1 = \frac{T_{indicated}}{D_1} \quad (2)$$

This applied force, F_1, is the same force referenced in equation (3).

$$T_2 = F_2 \times (D_1 + D_2) \quad (3)$$

To minimize confusion, I will rename T_2 $\boldsymbol{T_{actual}}$.

$$T_{actual} = F_2 \times (D_1 + D_2) \quad (4)$$

From equation (2), I know

$$F_1 = \frac{T_{indicated}}{D_1} \quad (2)$$

Force F_1 is the same as F_2; it is just the applied force. I can combine equations (2) and (4) to get

$$T_{actual} = \frac{T_{indicated}}{D_1} \times (D_1 + D_2) \quad (5)$$

Which is the same as

$$T_{actual} = T_{indicated} \times (1 + \frac{D_2}{D_1}) \quad (6)$$

Notice that when distance 2 is zero inches, our actual torque is the same as our indicated torque.
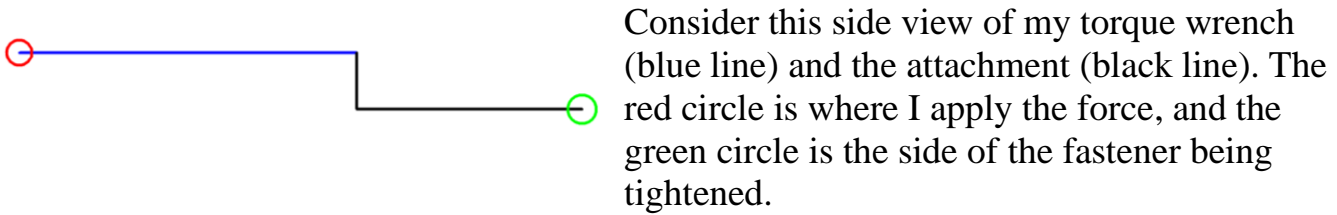
The longer we make our extension, the larger our actual torque for a given indicated torque. Distance 2 provides us with a torque multiplier. For example, if distance 2 equals distance 1, we have a distance divided by itself, which is 1:

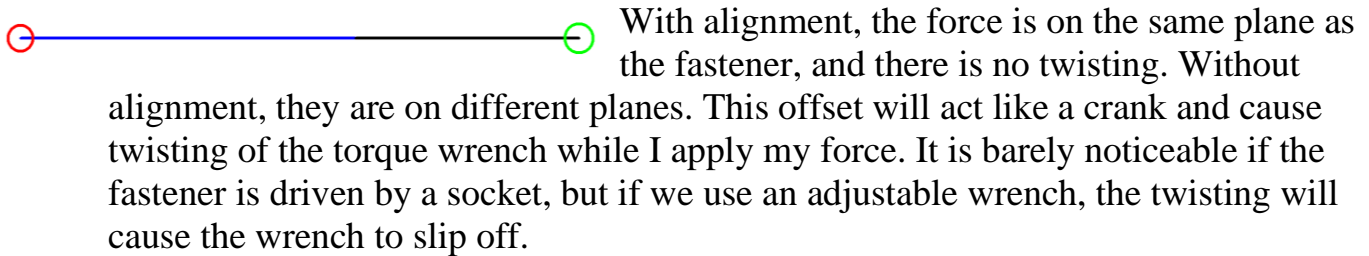$$T_{actual} = T_{indicated} \times (1 + 1)$$

$$T_{actual} = 2 \times T_{indicated}$$

If my torque wrench indicates 100 inch-pounds, the actual torque is 200 inch-pounds.

There is one more piece of the puzzle. If I am going to add something to the torque wrench, I do not want to develop any unwanted twisting.


Consider this side view of my torque wrench (blue line) and the attachment (black line). The red circle is where I apply the force, and the green circle is the side of the fastener being tightened.

Contrast this with:

With alignment, the force is on the same plane as the fastener, and there is no twisting. Without alignment, they are on different planes. This offset will act like a crank and cause twisting of the torque wrench while I apply my force. It is barely noticeable if the fastener is driven by a socket, but if we use an adjustable wrench, the twisting will cause the wrench to slip off.

In other words, the major axis of the adjustable wrench must line up with the major axis of the torque wrench's rod to eliminate twisting. This will become clearer when you see the entire assembly.

I will present my attachment and then return to equation (6).

Fabricating the Attachment
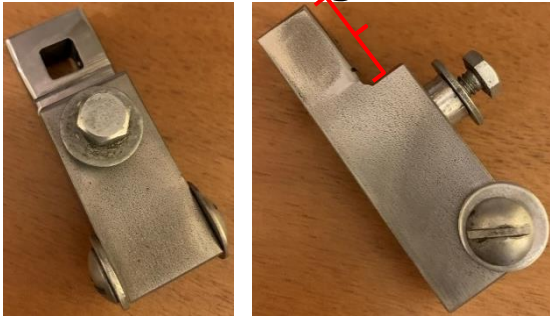
Here is my attachment. It was cut from a bar of 1-inch by 1-inch mild steel about 3-inches long.

The cut-out in the block (red bracket) ensures that the drive on the torque wrench only contacts in the square hole and does not bind up on the block's body.

I cut the square hole by first drilling a 3/8-inch diameter hole. Then I scribed the square outline. With a lot of elbow grease, I filed until my square drive fit.

Ø3/8 in   Ø1/16 in
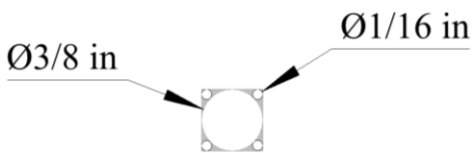
If I had to do it again, I would have first drilled 1/16-inch holes tangent to the corners and then drilled the 3/8-inch hole. This will reduce the amount of filing.

# Installing the Attachment

I feed the bolt with spacer through

the hole in the handle of my adjustable wrench.

The washers on the flanks of the attachment (blue arrows) limit the wrench's side to side motion. If this small pivoting causes a reduction in accuracy, I will make blocks to replace the washers that are snug against the wrench.

The attachment, loaded with the adjustable wrench, snaps onto the 3/8-inch drive. If you look close, you will see a hole in the side of the steel block that engages the spring-loaded ball in the drive.
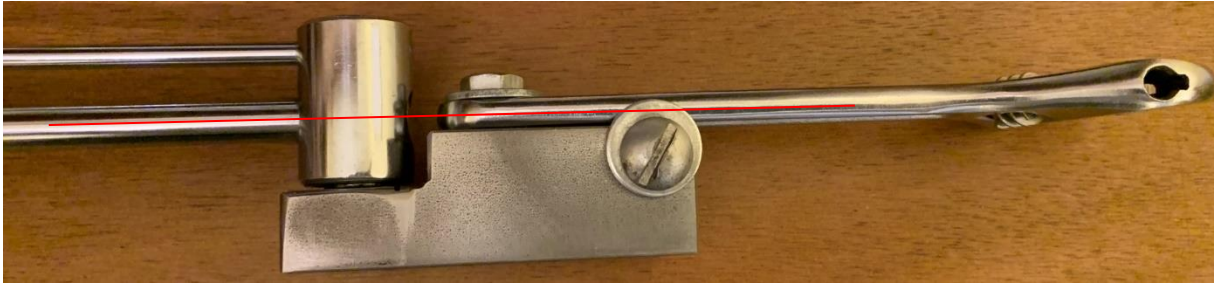
This side view shows how the adjustable wrench is aligned with the bar (red line).

I visualized a bolt held in the adjustable wrench and measured from its center to the center of the square drive. This is my Distance 2 and came out to 6.3-inches. Variation in bolt head size will affect this distance, but I don't think it is significant because my torque wrench is not that precise.

What I failed to predict was that the two wrenches would not be in alignment.

I modified my attachment, so the edge of the adjustable wrench could be supported by a screw. This put the two wrenches back in alignment.

Calibration

I already measured from the pin in the handle of the torque wrench to the center of the square drive. That is my Distance 1 at 13.7-inches.

Returning to equation (6), we have

$$T_{actual} = T_{indicated} \times (1 + \frac{D_2}{D_1}) \quad (6)$$

$$T_{actual} = T_{indicated} \times (1 + \frac{6.3 \; inches}{13.7 \; inches})$$

$$T_{actual} = 1.46 \times T_{indicated} \quad (7)$$

Testing

Before I can test my new tool, I had to make a device that will give me a consistent and known torque.

The Test Fixture

I selected a heavy steel piece of square tubing. At the left end I clamped a chunk of steel. The end of the C-clamp rests on a pile of wood[3] supported by a digital scale.

On the right end, I clamped a threaded bar able to accept a ¼-20 bolt. Then I threaded in a bolt that was long enough to pass through two bars drilled for clearance. This area was coated with grease. The assembly was clamped into my bench vise.

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[3] I later replaced the wood with an adjustable machinists jack.

The Calibration Procedure

My goal is to have a known and repeatable torque; the exact value is not important.

First, I zeroed my scale with just the wood on it. Next, I attached my digital level to the bar. I lowered the end of the C-clamp down on the wood. I adjusted the stack until the bar was approximately level. Then I zeroed the level.

I recorded the weight in grams, measured by the scale, and measured the distance from the center of the C-clamp's screw to the pivot nut at the other end. Knowing the weight and distance, I am able to calculate the torque.

To use this set-up, I slide the scale and stack of wood out of the way. My torque wrench goes on the nut on the right end of the bar. When the digital level reads zero, I know I have generated the calculated torque.

For example, I measured 3324 grams and a distance of 19.3 inches. I convert grams to pounds by multiplying by $\frac{2.2}{1000}$. Multiplying by the distance give me torque:

$$torque = 3324 \; grams \; \times \frac{2.2}{1000} \frac{pounds}{grams} \times 19.3 \; inches = 141 \; inch - pounds$$

With my torque wrench on the bolt, I apply a force on the handle until the digital level reads zero. I then take a picture of the scale for later analysis.

A Calibration Run

I ran this test over a range of torques to see how the actual applied torque compared to the indicated torque. I used a ruler to measure the distance between major tick marks plus the distance from the lower tick mark to the center of the pointer. These distances were ued to estimate the indicated torque.
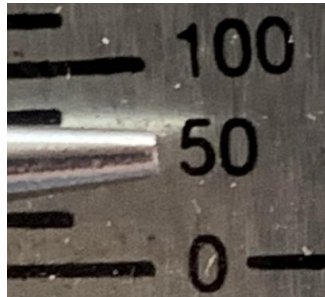
Actual torque was 52 inch-pounds.

100 x (0.47)= 47 inch-pound scale

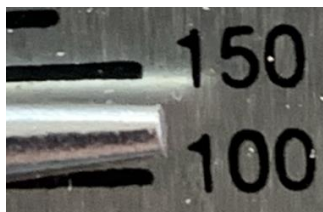Correction factor (actual/scale) = **1.11**

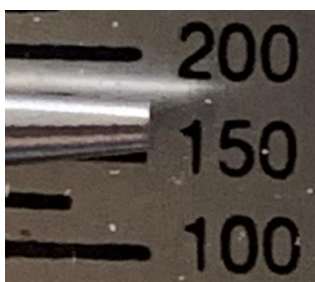Actual torque was 104 inch-pounds.

50 + (100)(0.4) = 90 inch-pound scale
Correction factor (actual/scale) = **1.16**

Actual torque was 141 inch-pounds

100 + (50)(2/5.2) = 119 inch-pound scale
Correction factor (actual/scale) = **1.18**

Actual torque was 186 inch-pounds

150 + (50)(1.3/5) = 163 inch-pound scale

Correction factor (actual/scale) = **1.14**

I can characterize these correction factors as 1.15 ± 0.04 or $1.15 \pm 3.5\%$.

Therefore, if I multiply the indicated reading by 1.15, it should be within 3.5% of the actual torque.

Testing The Extension

The extension has been added to my torque wrench, such that they are in alignment.

This time I used a digital caliper to measure distances in the picture.

I read $(0.913/1.456)(100) = 62.7$ inch-pounds[4]. My calibration factor is 1.15 ± 0.04. Therefore, the corrected indicated torque is $(1.15 \pm 0.04) \times 62.7 = 72.1 \pm 2.5$ inch-pounds.

From page 8, we know that

$$T_{actual} = 1.46 \times T_{indicated} \quad (7)$$

My corrected indicated torque is 72.1 ± 2.5 inch-pounds, so this predicts that my actual torque is

$$T_{predicted\ actual} = 1.46 \times (72.1 \pm 2.5\ inch - pounds)$$

$$T_{predicted\ actual} = 105.3 \pm 3.7\ inch - pounds$$

I, therefore, expect to see 102 to 109 inch-pounds.

The torque set up in my test fixture was 110 inch-pounds, so my predicted actual torque is 1 inch-pound or about 1% higher than expected.

If anyone can see sources of error I have missed, please let me know.

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[4] I will carry three places in all numbers until the end where I will round to the nearest inch-pound.

Using Allen Wrenches in the Attachment
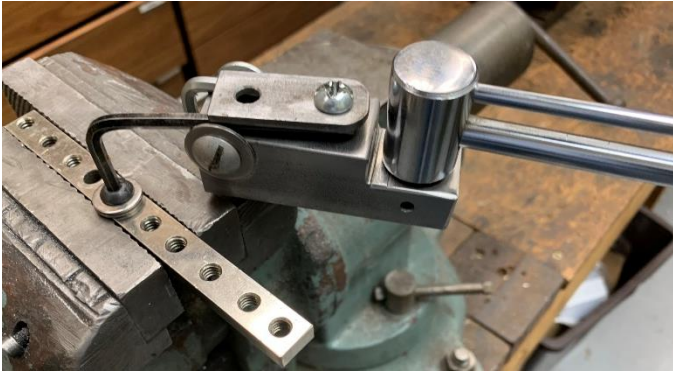
I have many Socket Head Cap Screw fasteners which take an Allen wrench. Sure, I can buy Allen wrenches that accept a standard 3/8-inch drive. But I've already got plenty of bare Allen wrenches. As a proof of concept, here is an Allen wrench bolted to my adapter. Distance 2 must be measured to get the correction factor.

No Math Calibration

A no-math way to get the correction factor is to revisit equation (6)

$$T_{actual} = T_{indicated} \times (1 + \frac{D_2}{D_1}) \quad (6)$$

I can write this as

$$T_{actual} = k \times T_{indicated} \quad (8)$$

Solving for k, I get

$$k = \frac{T_{actual}}{T_{indicated}} \quad (9)$$

Given you have a known actual torque and the corresponding indicated torque, you can calculate k using equation (9). Then you can use equation (8) with any indicated torque to find the actual torque.

Adjustable wrench at 90° from the Torque Wrench

Here is an [excellent video](#) that demonstrates that when you put an extension bar at 90° from the major axis of the torque wrench, the reading is the same as without the bar. My question is – why is this true?
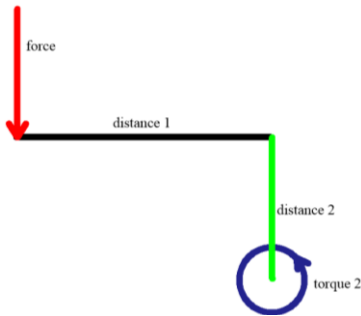
I again have my force applied to the handle of my torque wrench. At distance 1 I connect my adjustable wrench, but this time it is at 90°. The claim, demonstrated in the video, is that torque 2 equals force times distance 1. Distance 2 has no effect. How can that be true?
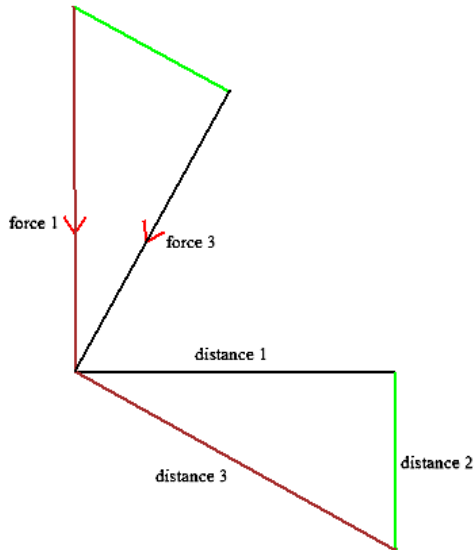
I have drawn a new figure that only looks at forces and distances. Recall that the force must be at 90° from the distance line for the equations in this article to work.

Without the adjustable wrench installed, force 1 multiplied by distance 1 develops a torque at the right end of distance 1.

Consider what happens when I add distance 2. The distance from the point where the force is applied to the drive is distance 3. I must calculate force 3, which is at 90° from the distance 3 line.
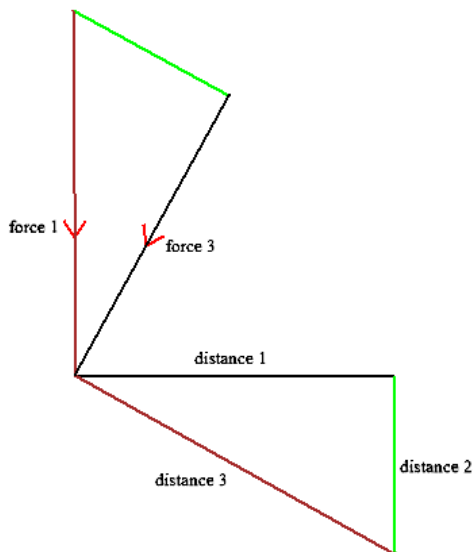
Dealing with the force is not as straight-forward. Let's sneak up on it.

When I set distance 2 to zero, my right triangle collapses. Distance 3 equals distance 1. Force 3 equals force 1. We are back in familiar territory.
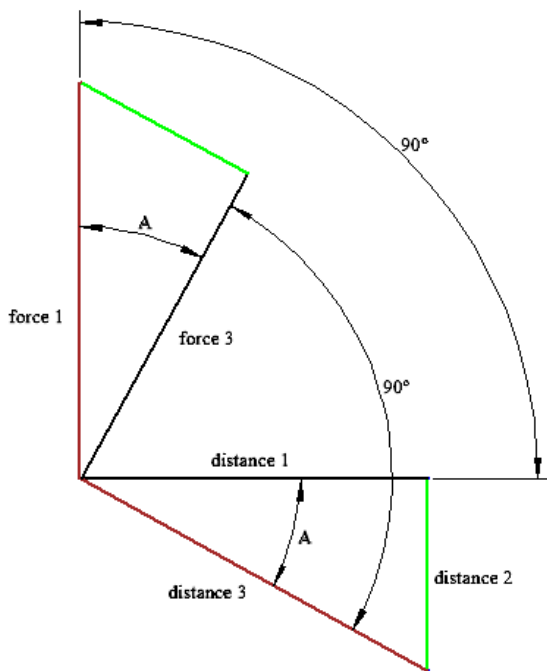
distance 1

distance 3 distance 2
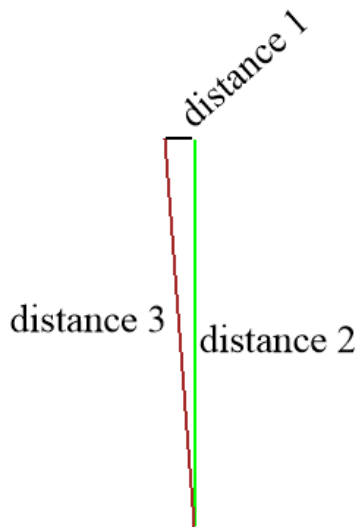
Next, consider the case of distance 2 being much longer than distance 1. We have distance 3 almost equal to distance 2, and the distance 3 line is almost at 90° relative to distance 1 line.
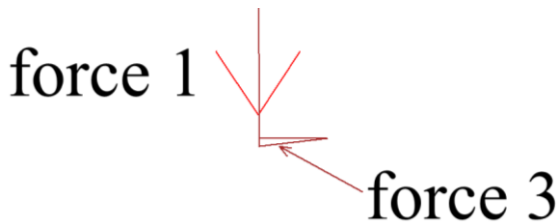
force 1

force 3

Looking at the forces, we still have force 1 at 90° from the distance 1 line. Force 3 must be at 90° from the distance 3 line. But since these forces are part of a right triangle, force 3 must be very small.

As distance 2 gets very long, force 3 gets very small.

Focusing on the angles, we have the force 1 line at 90° from the distance 1 line and the force 3 line at 90° from the distance 3 line. Call the angle between the distance 1 line and the distance 3 line "A°."

90°

A

force 1

force 3

90°

distance 1

A

distance 3

distance 2

Is the angle between the force 1 line and the force 3 line really A°? Lets reason this out.

Starting at the distance 3 line, we know that the force 3 line is at 90° from it. The force 1 line is 90° from the distance 1 line, which is A° from the distance 3 line. This means that the force 1 line is 90° + A° from the distance 3 line.

I can now subtract the angular position of the force 3 line from that of the force 1 line to find the angle between them: (90° + A°) − 90° = A°. Therefore, yes, the angle between the force 1 line and the force 3 line really is A°.

Using trigonometry, I know that

$$\text{Cosine } A° = \frac{force_3}{force_1} \quad (11)$$

And

$$\text{Cosine } A° = \frac{distance_1}{distance_3} \quad (12)$$

I can set these equations equal to get

$$\frac{force_3}{force_1} = \frac{distance_1}{distance_3} \quad (13)$$

On page 15, I talked about force 3 shrinking when distance 3 became much larger than distance 1. Equation (13) is saying the same thing. When distance 3 is much longer than distance 1, their ratio is very small. This means that force 3 must be much smaller than force 1.
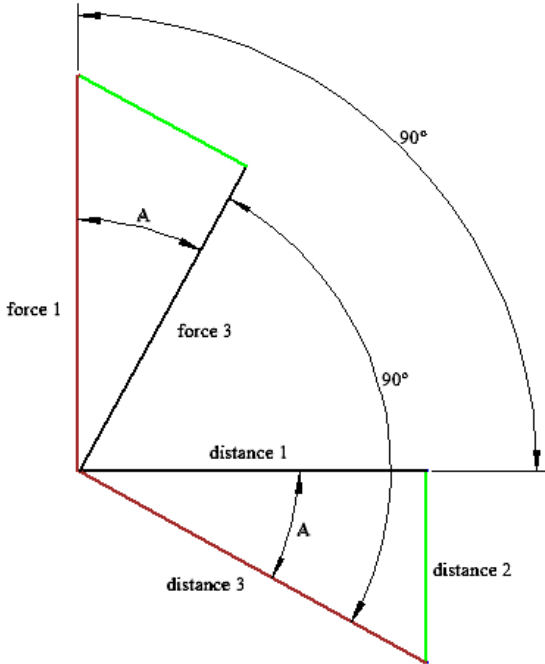
From page 3, I know that

$$T_1 = F_1 \times D_1 \quad (1)$$

Torque, T_1, equals a force, F_1, acting at a distance, D_1.
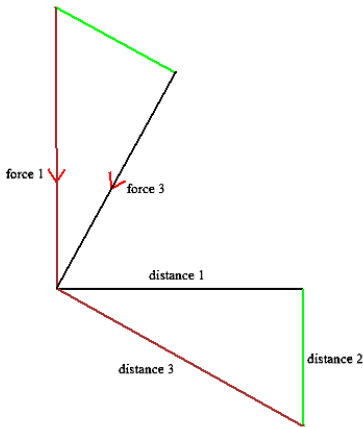
The torque indicated on my torque wrench is

$$T_{indicated} = F_1 \times D_1 \quad (14)$$

When I add in distance 2, I am dealing with force 3, and distance 3 but equation (1) still applies, but now we are talking about the actual applied torque:

$$T_{actual} = F_3 \times D_3 \quad (15)$$

Tying this all together is

$$\frac{force_3}{force_1} = \frac{distance_1}{distance_3} \quad (13)$$

Equation 1 gives me force 1, and equation 15 gives me force 3. Put these into equation (13) to get

$$\frac{\left[\frac{T_{actual}}{D_3}\right]}{\left[\frac{T_{indicated}}{D_1}\right]} = \frac{distance_1}{distance_3} \quad (13)$$

$$\frac{[T_{actual}]}{[T_{indicated}]} \times \frac{distance_1}{distance_3} = \frac{distance_1}{distance_3} \quad (14)$$

Dividing both sides by $\frac{distance_1}{distance_3}$ I get

$$\frac{[T_{actual}]}{[T_{indicated}]} = 1 \quad (15)$$

or

$$T_{indicated} = T_{actual} \quad (16)$$

Notice that the length of the extension is not in the equation when the extension is at 90° to the torque wrench. This is consistent with this YouTube video. Now I understand the underlying logic.

Acknowledgments

Thanks to Dave Kellogg, John Cooper, and Gadgeteer for supplying the equation that relates measured and actual torque. Thanks also to Bill Hudson, Gregg Kricorissian, Larry Guthrie, instar sam, John Herrmann, plus rebuilder1954, Murph1090, and katy of homemadetools.net for their insights.

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Rick Sparber
Rgsparber.ha@gmail.com
Rick.Sparber.org