Torque

Torque is defined as the measure of tendency of a force to cause rotational motion.

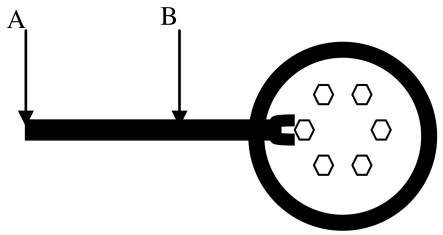
Torque is the result of a force acting a distance from an axis of rotation and is calculated as

$T = Fd_{\perp}$ units: Nm

Where F = magnitude of force (N)
$d_{\perp}$= moment arm (m)

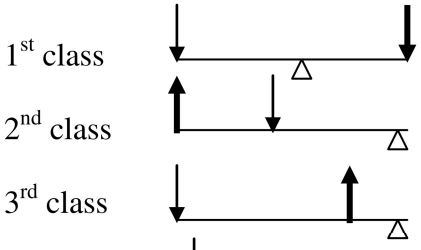
The moment arm is a measure of the perpendicular distance between the line of application of the force and axis of rotation. This happens to be the shortest distance between the line of application of the force and axis of rotation.

This is something you already knew! Consider taking off the lug nuts off a wheel:



At which point, A or B, would you push? Clearly that would be point A. Why? Because you know that you can exert a greater torque on the lug nut, and hopefully you'll be able to get the nut off! If not, what can you do? Consider that you have two options: 1) increase magnitude of force 2) increase the moment arm. See if you can come up with a solution for how to increase force and moment arm.

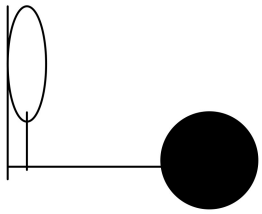
When discussing torque, often we look at how the force is applied about an axis relative to a resistive force. We then classify different lever systems as being either 1st, 2nd or 3rd class levers.



Consider that the thin arrow ↓ represents a resistive force while the thick arrow ↑ represents a motive force. Which of these levers would you use to:

1. Lift a heavy object?
2. Move the end point of the lever at high speeds?

The body is put together primarily with 3rd class levers. Consider the elbow joint:



Identify the fulcrum, motive & resistive forces, as well as the moment arm for each force?

Can you draw the elbow angle along with associated lever parameters with the elbow in full extension? At different elbow angles?

What happens to the moment arm of the muscle force when the elbow is fully extended compared to when the elbow is at 90 degrees?

Does the elbow angle have anything to do with how much weight can be lifted? Why or why not?

Angular Laws of Motion

Rewriting Newton's Laws of Motion using angular terminology, we arrive at:

1. Law of Uniform Angular Motion
   An object that is in angular motion will continue in its state of angular motion unless a Torque is applied to it.

2. Law of Angular Acceleration
   The angular acceleration an object undergoes is proportional to the Torque applied to it and inversely proportional to the moment of inertia.

3. Law of Action-Reaction
   For every Torque applied, there is an equal and opposite Torque.