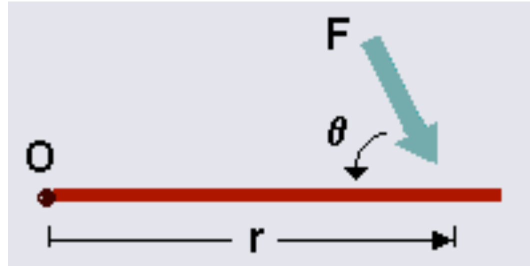
Torque



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Relationship between force **F**, torque **τ**, linear momentum **p**, and angular momentum **L** in a system which has rotation constrained in one plane only (forces and moments due to gravity and friction not considered).

Torque, **moment** or **moment of force** (see the terminology below), is the tendency of a force to rotate an object about an axis,[1] fulcrum, or pivot. Just as a force is a push or a pull, a torque can be thought of as a twist to an object. Mathematically, torque is defined as the cross product of the lever-arm distance and force, which tends to produce rotation.

Loosely speaking, torque is a measure of the turning force on an object such as a bolt or a flywheel. For example, pushing or pulling the handle of a wrench connected to a nut or bolt produces a torque (turning force) that loosens or tightens the nut or bolt.

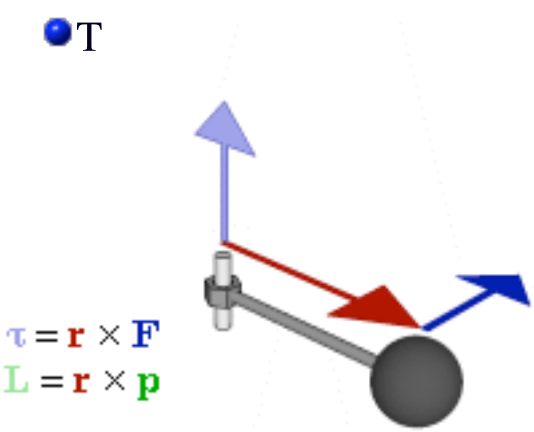
The symbol for torque is typically τ, the Greek letter *tau*. When it is called moment, it is commonly denoted *M*.

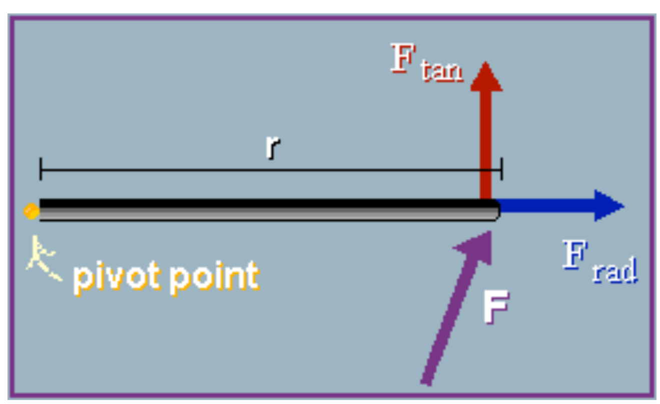
The magnitude of torque depends on three quantities: the force applied, the length of the *lever arm*[2] connecting the axis to the point of force application, and the angle between the force vector and the lever arm. In symbols:

$$\boldsymbol{\tau} = \mathbf{r} \times \mathbf{F}$$
$$\tau = rF\sin\theta$$

where

τ is the torque vector and τ is the magnitude of the torque,
r is the displacement vector (a vector from the point from which torque is measured to the point where force is applied), and r is the length (or magnitude) of the lever arm vector,
F is the force vector, and F is the magnitude of the force,
× denotes the cross product,
θ is the angle between the force vector and the lever arm vector.
The length of the lever arm is particularly important; choosing this length appropriately lies behind the operation of levers, pulleys, gears, and most other simple machines involving a mechanical advantage.



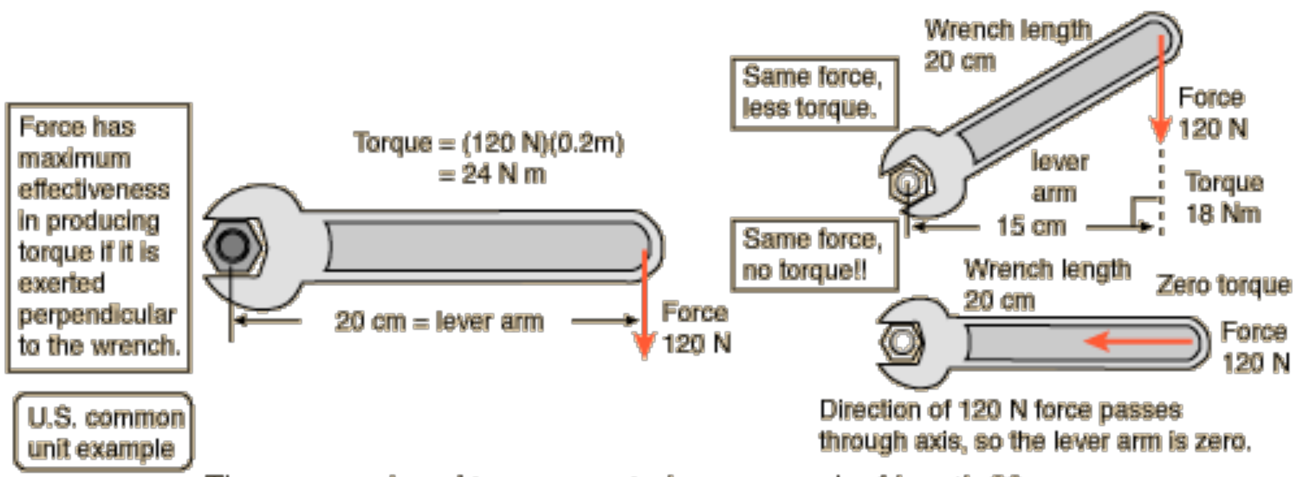


Torque

A torque is an influence which tends to change the rotational motion of an object. One way to quantify a torque is

Torque = Force applied x lever arm

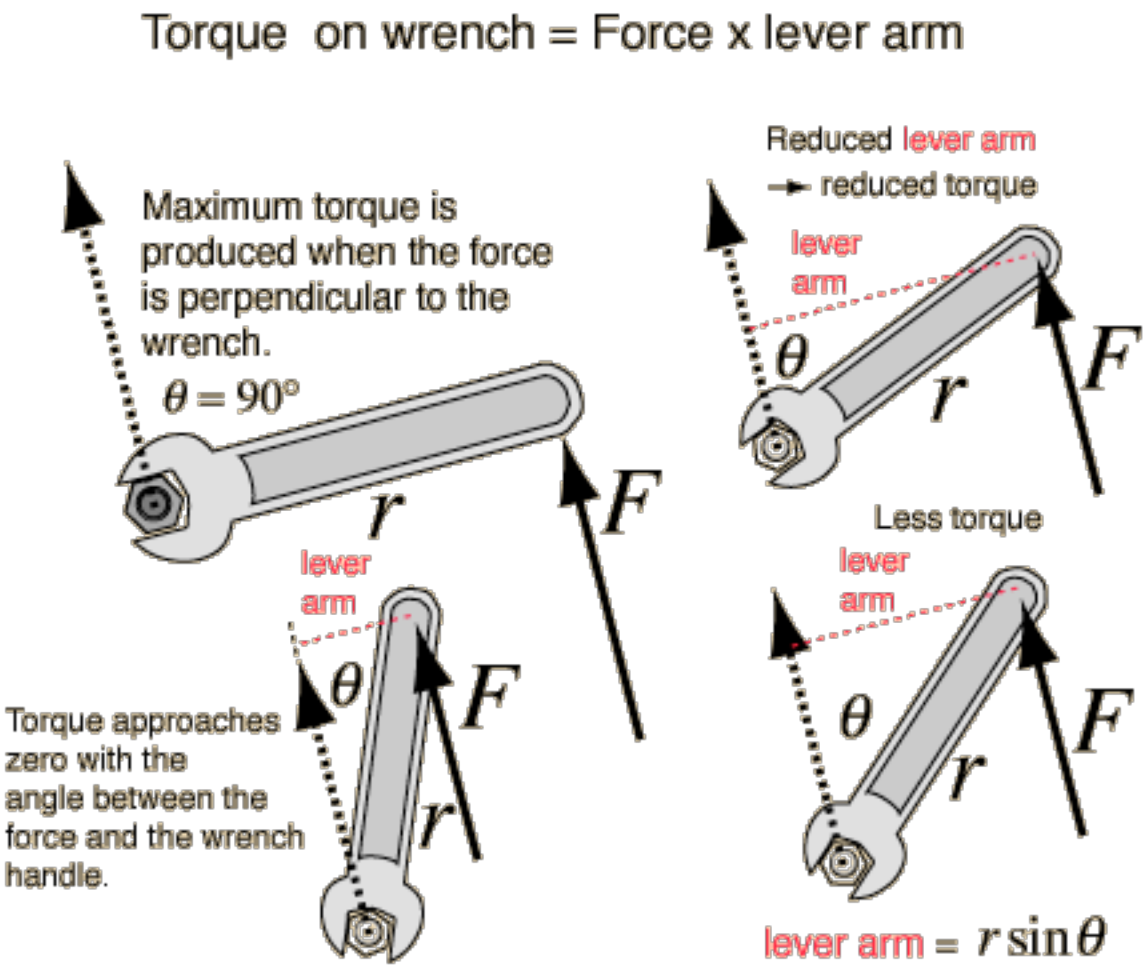
The lever arm is defined as the perpendicular distance from the axis of rotation to the line of action of the force.



Three examples of torque exerted on a wrench of length 20 cm.

[Torque calculation]
Torque expressions:

Lever Arm



The magnitude of the torque with respect to a given axis of rotation can be approached as the force times the lever arm with respect to that axis. The lever arm is the perpendicular distance from the axis of rotation to the line of action of the force. The direction of the torque is given by the right hand rule.

Right Hand Rule for Torque

Torque is inherently a vector quantity. Part of the torque calculation is the determination of direction. The direction is perpendicular to both the radius from the axis and to the force. It is conventional to choose it in the right hand rule direction along the axis of rotation. The torque is in the direction of the angular velocity which would be produced by it in the absence of other influences. In general, the change in angular velocity is in the direction of the torque.