Torque

General Physics

Lecture(7)

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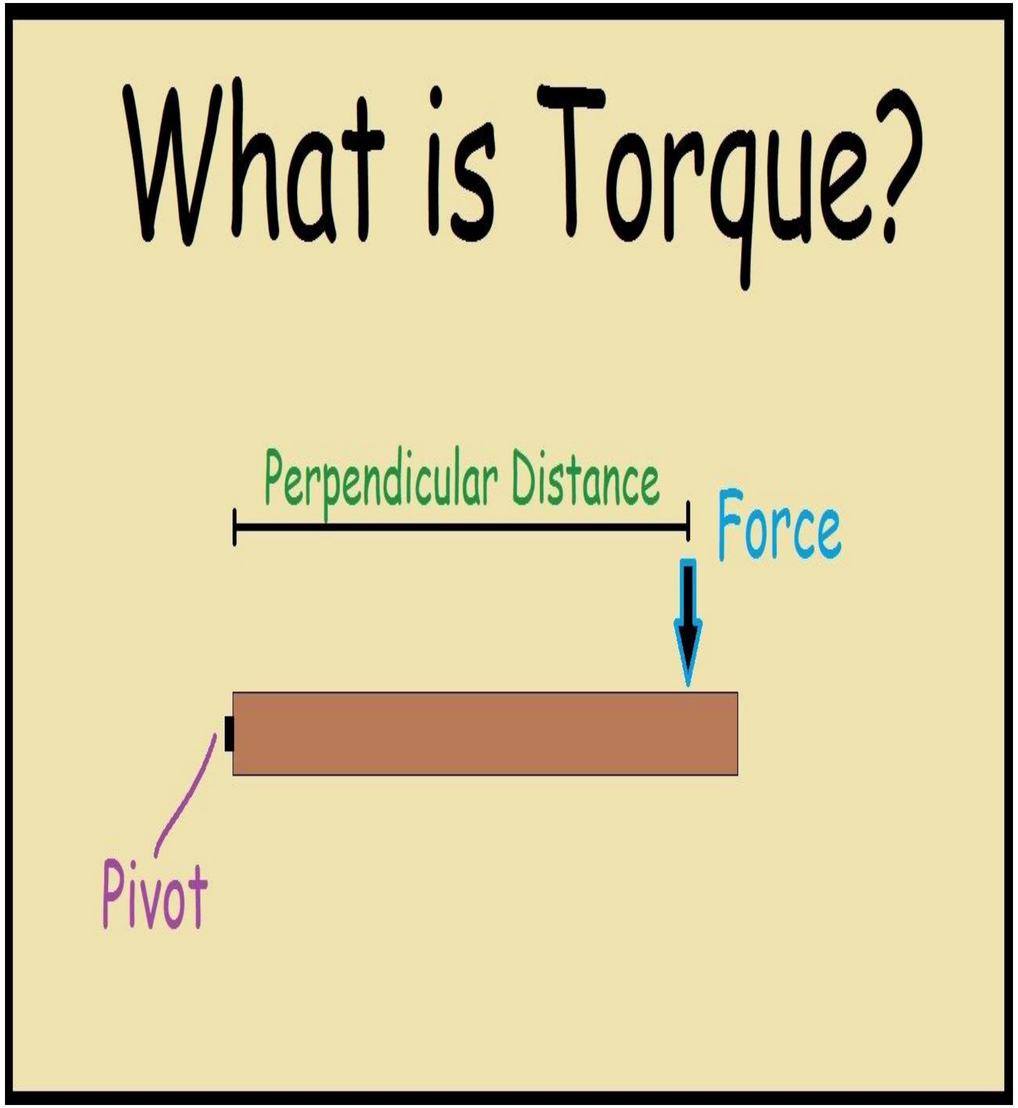
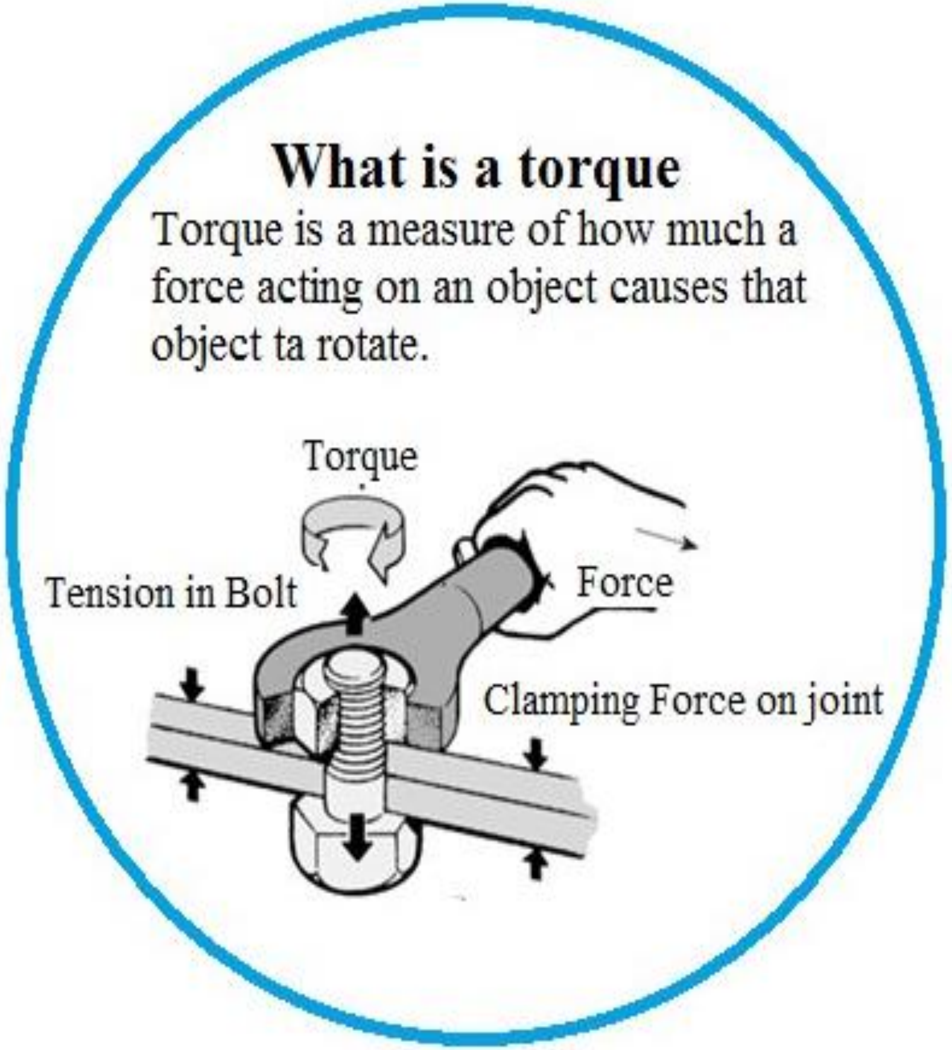
- **In physics and mechanics, torque is the rotational tendency of linear force.** is also referred to as the **moment of force** (or **moment**). It describes the rate of change of angular momentum that would be imparted to an isolated body.
- It is a twist or turning force on an object. Torque is calculated by multiplying force and distance. It is a vector quantity, meaning it has both a direction and a magnitude. Either the angular velocity for the moment of inertia of an object is changing, or both.
- Mathematically, Torque is defined as the product of the magnitude of the perpendicular component of the force and the distance of the line of action
- Torque is a measure of how effective a given force is at twisting or turning something.

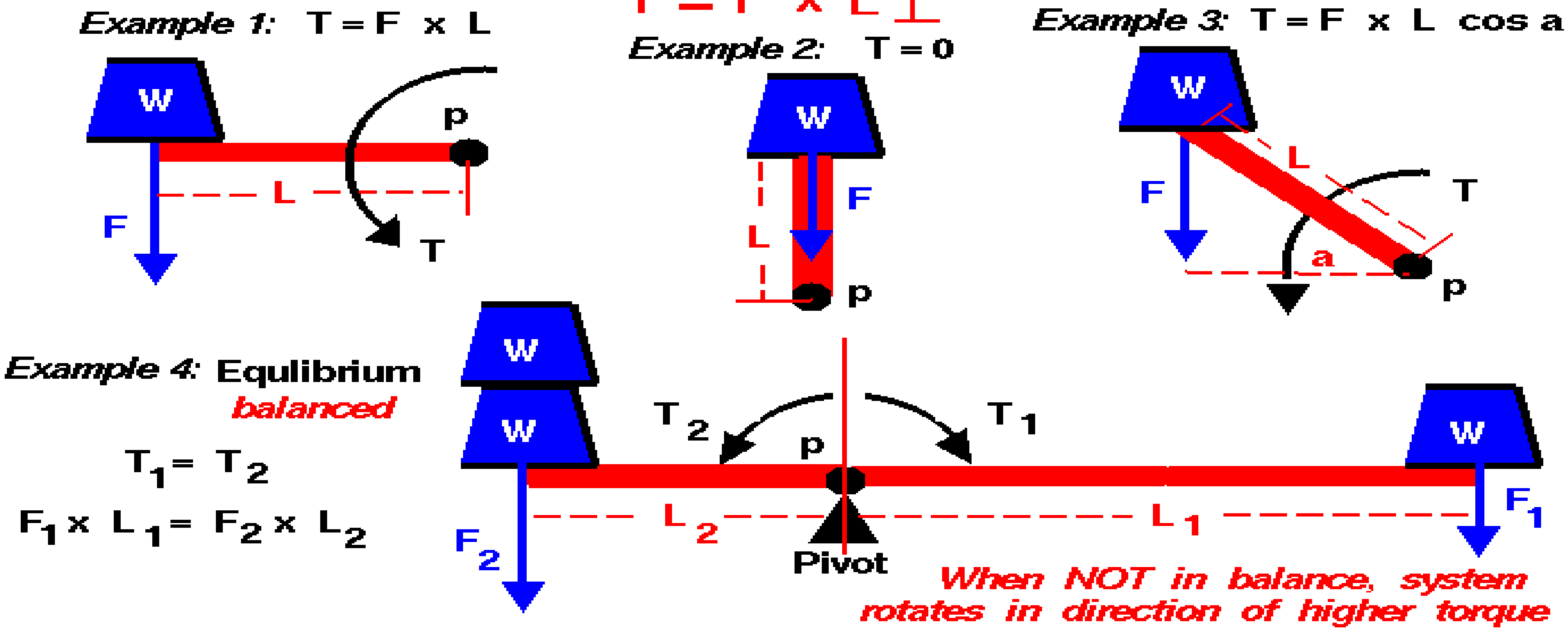

What is Torque?
Perpendicular Distance
Force
Pivot


What is a torque
Torque is a measure of how much a force acting on an object causes that object ta rotate.
Torque
Tension in Bolt
Force
Clamping Force on joint

Torque (Moment)

The Torque (T) about a point (p) is equal to the Force (F) times the distance (L) measured perpendicular to the force.

$$T = F \times L_{\perp}$$



Torque and Energy

- There are translational and rotational force, related to the translational and rotational energy
- The rotational kinetic energy of a rigid object rotating with angular velocity ω is :

$$K = \frac{1}{2} I\omega^2$$

- The translational kinetic energy

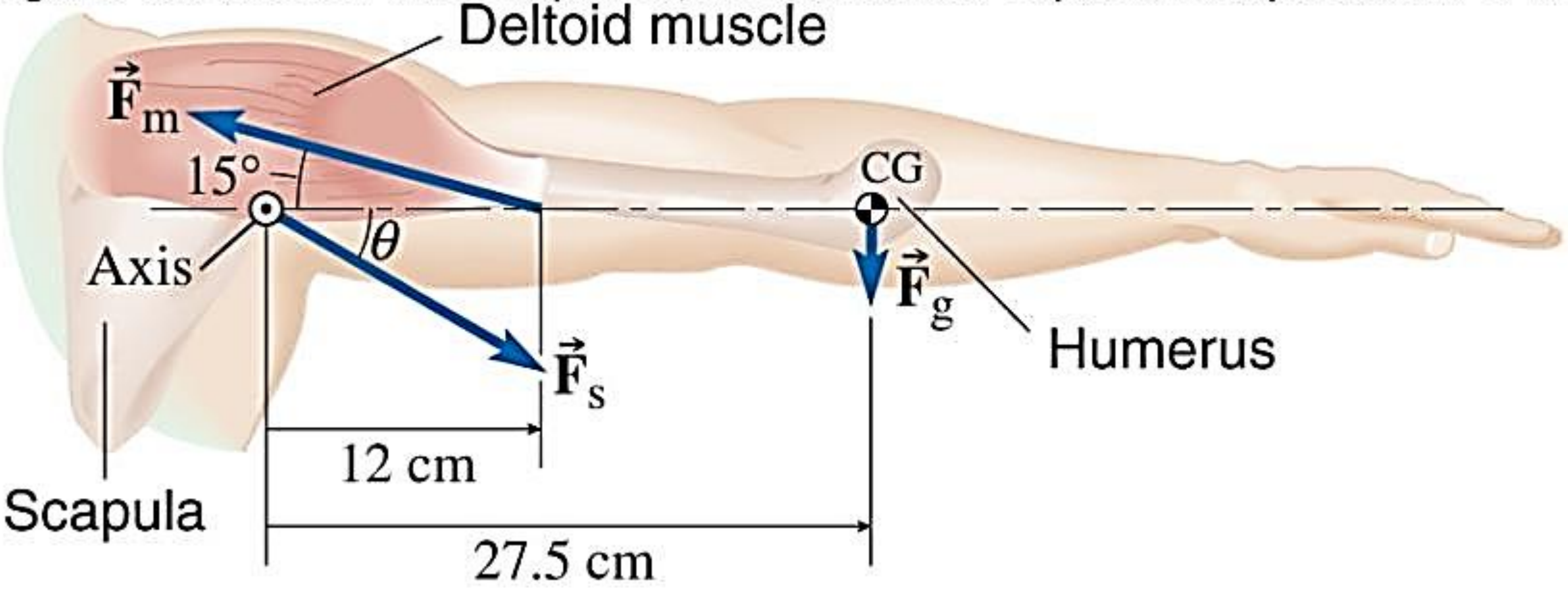
$$K = \frac{1}{2} mv^2$$

In Summery

- The International System of Measurement units (SI units) used for torque is (Newton.meters) or $(N.m)$. Even though newton-meters are equal to Joules, since torque isn't work or energy so all measurements should be expressed in newton-meter.
- Because rotations have directions, we assign the (+)sign to torques that cause counter clockwise rotations, and (–) sign to torques that cause clockwise rotations.
- The magnitude of torque depends on how much force is applied, the length of the lever arm that connects the axis to the point where the force is applied, and the angle between the force vector and the lever arm.

Example
Equilibrium in the Human Body

The deltoid muscle exerts $\mathbf{F}_m$ on the humours bone as shown. The force does two things. The vertical component supports the weight of the arm and the horizontal component stabilizes the joint by pulling the humours in against the shoulder.
There are three forces acting on the arm: its weight ($\mathbf{F}_g$), the force due so the deltoid muscle ($\mathbf{F}_m$) and the force of the shoulder joint ($\mathbf{F}_s$) constraining the motion of the arm.



Solution

$$\sum \tau = 0$$

$$\tau_g + \tau_m = 0$$

$$-F_g r_g + F_{m\perp} r_m = 0$$

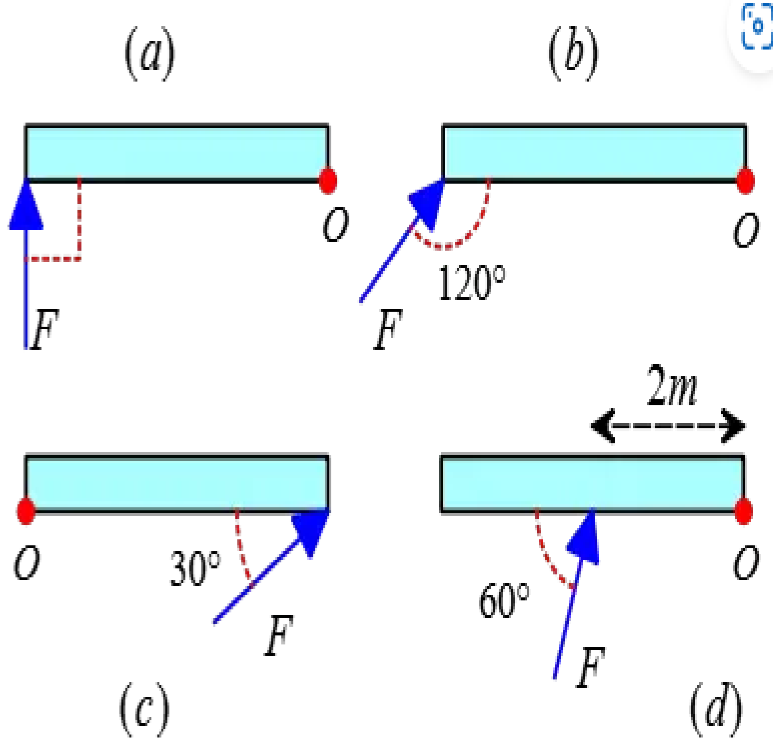
$$-F_g r_g + F_m \sin 15° r_m = 0$$

$$F_m = \frac{F_g r_g}{r_m \sin 15°} = \frac{(30\,\mathrm{N})(0.275\,\mathrm{m})}{(0.12\,\mathrm{m})\sin 15°} = 266\,\mathrm{N}$$

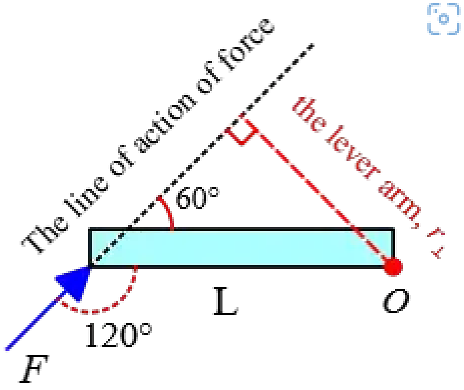
- **Solved problem: In each of the following diagrams, calculate the torque (magnitude and direction) about point *O* due to the force $\vec{F}$ of magnitude 10N applied to a 4 m rod. Both the force $\vec{F}$ and the rode lie in the plane of the page.**

- **<u>Solution</u>**

we must identify the line of action and then the lever arm $r_{\perp}$.



- (a) In this figure, the line of action of the force is already perpendicular to the axis of rotation. Thus, the lever arm is the full distance between the point of application of the force *F* and the point *O*, i.e., $r_\perp$=4m . Therefore, the torque magnitude τ about point *O* is calculated as:
- $\tau = r_\perp F = 4 \times 10 = 40\ N.m$
- (b) To find the torque of this configuration, extend the force *F* and draw a line perpendicular to it so that it passes through the axis of rotation.
- In this case, we use the formula:
- $r_\perp = LSin\theta = 4\sin 60^o = 2\sqrt{3}m$
- $\tau = r_\perp F = 2\sqrt{3}.10 = 20\sqrt{3}N$.m



- (c) Again, identify the lever arm and compute the magnitude of the torque associated with this force about point *O*.
- $\tau = r_{\perp}F = (LSin\theta)F = (4\sin 30)10 = 20N.m$
- (d) In this configuration, the angle between the force line and the direction of the rod is $\theta = 60^o$. Hence, the magnitude of the torque about the axis of rotation *O* is found as
- $\tau = (Lsin\theta)F = (4sin60)10 = 20\sqrt{3}\,N.m$