Torque & Equilibrium

12PHYS - Mechanics

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Starter

$$F = ma \tag{1}$$

1. State what each letter stands for
2. Give the units for each letter
3. Rearrange the equation for m and a
4. Derive the SI units for F (not Newtons)

For a car of **mass 1500kg** which is accelerating at $3.7ms^{-2}$:

1. What net force is needed to maintain this acceleration?
2. If the engine is producing $6000N$ of thrust, what is the difference and what happened to it?

Torque (τ)

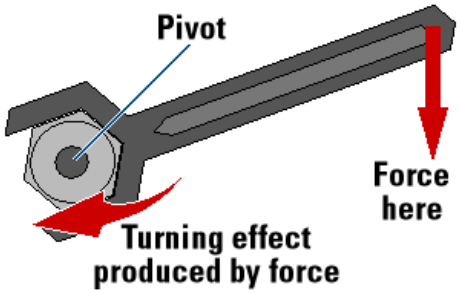
Torque can be thought of as the **turning effect** around a **pivot**. Torque is sometimes known as **moment** or **leverage**.

$$\tau = Fd_{\perp} torque = Newtons \times metres torque = \text{Newton meters (Nm)} \tag{2}$$

$$F = \text{force in Newtons} d_{\perp} = \text{perpendicular distance of force from pivot} \tag{3}$$

Torque (τ)

- A small force at a small distance produces a small torque,
- the same small force at a larger distance produces a larger torque.



Question 1

A force of 9N acting up at a distance of 10cm is needed to lift the top off a bottle of soft drink. **Calculate the torque applied.**

Question 1: Answer

A force of 9N acting up at a distance of 10cm is needed to lift the top off a bottle of soft drink. **Calculate the torque applied.**

$$\tau = Fd_{\perp}\tau = 9 \times 0.1\tau = 0.9\text{Nm anticlockwise} \tag{4}$$

Question 2

Calculate the torque applied if the lever is stretched to 75cm.

Question 2: Answer

Calculate the torque applied if the lever is stretched to 75cm.

$$\tau = Fd_{\perp}\tau = 9 \times 0.75\tau = 6.75\text{Nm anticlockwise} \tag{5}$$

Question 3

Calculate the torque applied if the lever is compressed to 1cm.

Question 3: Answer

Calculate the torque applied if the lever is compressed to 1cm.

$$\tau = Fd_{\perp}\tau = 9 \times 0.01\tau = 0.09\text{Nm anticlockwise} \tag{6}$$

Question 4: Does torque have a direction?

Yes, and you must always state which direction it is acting in.

Clockwise or Anticlockwise

Torque & Equilibrium

But, What Is Equilibrium?

Newton's First Law tells us equilibrium is when an object is **at rest** or **moving uniformly**.

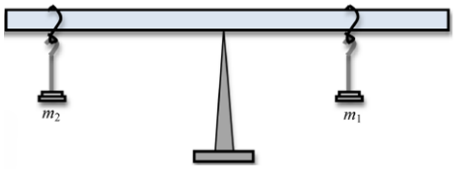
For this to occur we need two things:

1. Sum of all forces to be 0
2. Sum of all torques to be 0

Okay, So Where Do We Use It?

Building bridges, setting up scaffolding, see-saws and more!

Question 1

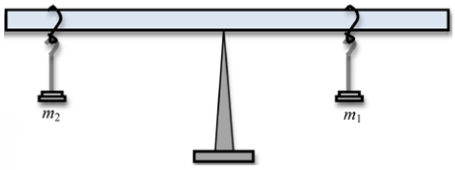


$m_1 = 2kg$, $d_1 = 15cm$, $m_2 = 1kg$, $d_2 = 30cm$

1. Calculate the clockwise and anticlockwise torques

2. Are they in balance?

Question 2



$m_1 = 7kg$, $d_1 = 65cm$, $m_2 = 13kg$, $d_2 = 35cm$

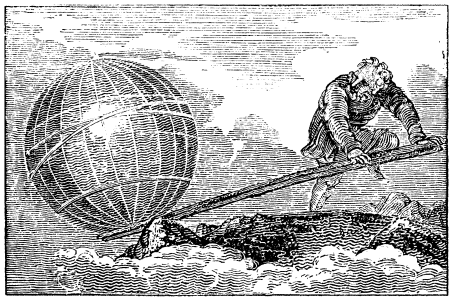
1. Calculate the clockwise and anticlockwise torques
2. Are they in balance?

Question 3

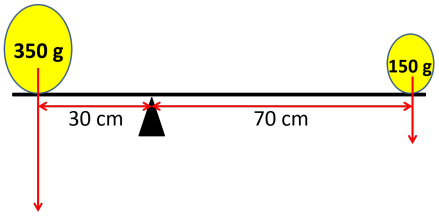
The rock has mass $1100kg$ and is at distance $50cm$ from the pivot. If Ash exerts $70N$ of downward force at a distance of $8m$ from the pivot can he move the rock?

Archimedes once said: *"Give me a place to stand and I will move the world"*

Question: Assuming the mass of the Earth is $5.972 \times 10^{24}kg$ at a distance of 1km from the pivot and Archimedes' mass is $75kg$, how long would his lever have to be?



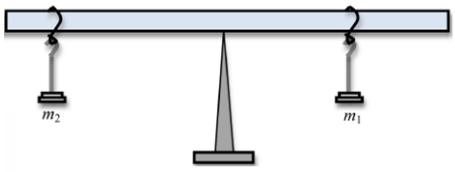
Starter



1. Calculate the clockwise torque
2. Calculate the anticlockwise torque
3. Is it balanced?

Torque & Equilibrium

The plank may not be massless. You may need to take it into account.



- The mass of the plank acts through its **center of gravity**
- Because the plank is uniform, this is the middle of the plank

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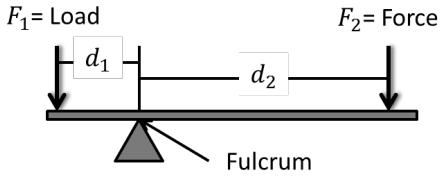
How To Solve A Torque Problem

1. Draw and label all forces on a diagram
2. Draw and label the distances between all forces and the **pivot**
3. Calculate all clockwise torque
4. Calculate all anticlockwise torque
5. Balance torques & forces

Question



$d_1 = 30cm$, $d_2 = 70cm$, $m_1 = 900g$, $m_2 = 300g$, seesaw mass $= 100g$.

1. Calculate the total anticlockwise moment
2. Calculate the total clockwise moment
3. Is it balanced?