

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?
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Torque (τ)

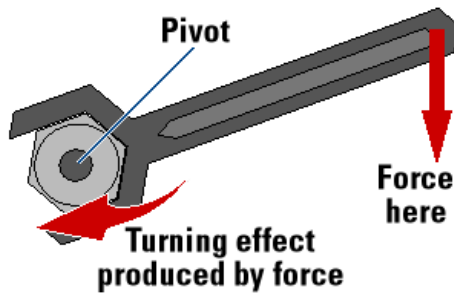
Torque can be thought of as the **turning effect** around a **pivot**. Torque is sometimes known as **moment** or **leverage**.

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

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

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.**

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

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.

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

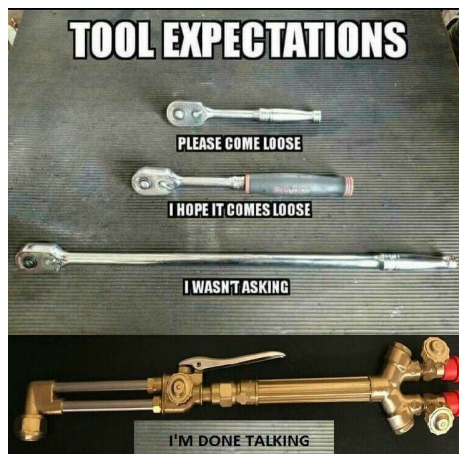
Question 3

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.

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



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**.

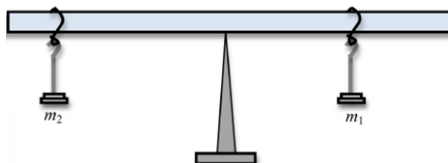
For this to occur we need two things:

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

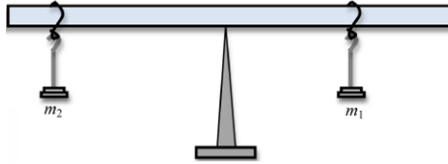


$$m_1 = 2\text{kg}, d_1 = 15\text{cm}, m_2 = 1\text{kg}, d_2 = 30\text{cm}$$

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?

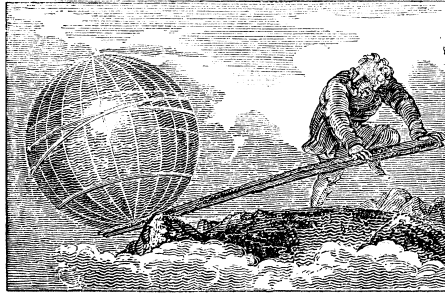
Question 3



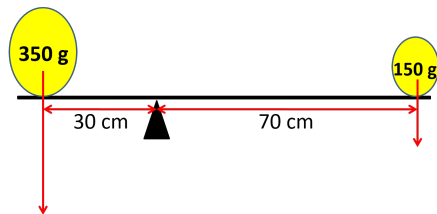
The rock has mass $1100kg$ and is at distance $50cm$ from the pivot. If Ash exerts $70N$ of downward force at a distance of $8m$ from the pivot can he move the rock?

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?



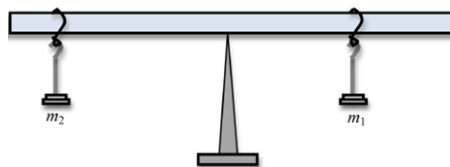
Starter



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

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

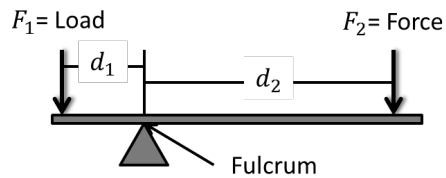


- The mass of the plank acts through its **center of gravity**
 - Because the plank is uniform, this is the middle of the plank
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How To Solve A Torque Problem

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
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Question



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

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