Torques

Definitions

The first condition for equilibrium:

The vector sum of all the external forces acting on the system must add up to be zero.

$$Fnet = \sum F = 0$$

Usually @ Level 2: "*Upward forces = downwards forces*".

The second condition for equilibrium:

The net torque acting on the system must add up to be zero.

$$\sum \tau = 0$$

Usually @ Level 2: "*The sum of the anticlockwise moments about any point is equal and opposite to the sum of the anticlockwise moments about that point*".

Equations

$\tau = Fd$	Torque [moment]	τ	N m
	Force	F	N
	displacement	d	m

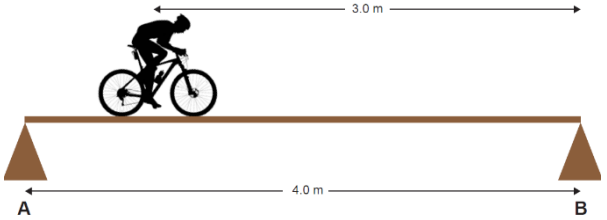
Questions

ENERGY (2021;3)

A cyclist bikes over a 4.0 m-long bridge and stops 3.0 m from the end. The bridge has a uniform mass of 700 kg. The combined mass of the rider and bike is 85 kg.

(a) State the conditions required for the bridge to be in equilibrium.

(b) Draw labelled arrows to represent all the forces acting on the bridge.



(c) Calculate the values of ALL the forces acting on the bridge.

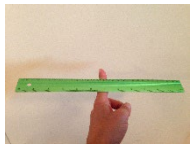
Terms

Torque: Turning force (not applied through the centre of mass) which causes the object to spin.
Torque is the rotational equivalent of a force.

Anti-Clockwise (or Counterclockwise): Rotating (or would rotate) in the opposite direction as the hands of an analogue clock.
Clockwise: Rotating (or would rotate) in the same direction as the hands of an analogue clock
Equilibrium: For a system to be in the state of equilibrium (not spinning or spinning at a constant rate), it must not experience any kind of linear acceleration or rotational acceleration.
Pivot point: The center point of any rotational system

Tips

For a uniform beam its weight acts downwards at the middle



To solve any torque question:

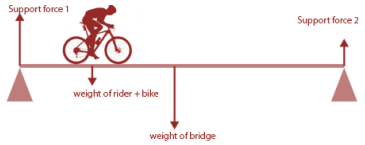
- Upward forces = downwards forces
- The sum of the anticlockwise moments about any point is equal and opposite to the sum of the anticlockwise moments about that point.

You can choose the point around which the torque is calculated. The point can be the physical pivot point of a system or any other point in space—but it must be the same point for all torques. If the second condition (net external torque on a system is zero) is satisfied for one choice of pivot point, it will also hold true for any other choice of pivot point.

Answers

(a) No net forces and no net torques.

(b)



(c) Weight force of bridge = 700 x 9.8 = 6860 N. Weight of person + bike = 833 N

Taking moments about B:

4 x F_A= (85 x 9.8 x 3) + (700 x 9.8 x 2) so F_A = 4055 = 4100 N

upward forces = downward forces

$F_A + F_B$ = (85 x 9.8) + (700 x 9.8)

$F_A + F_B$ = 7693 N so F_B = 7693 – F_A = 3638 = 3600 N