## Torque and Moment

At the end of this lecture you should

- Understand what is meant by a torque (moment of a force)
- Be able to perform calculations to demonstrate your understanding


## Torque (moment of a force)



Which of these three forces is most likely to loosen the tight bolt? Why?

## Torque (moment of a force)

The turning effect of a force F about a given axis is called its torque. A torque (also called 'moment' of a force) is a 'turning force'. It gives a measure of how much 'turning effect' a force has about a given axis.

Torque = force x perpendicular distance from line of action of force to the pivot

## Example 1. 'Opening doors'

## A boy pulls on a door handle.

A) Calculate the torque about the hinge.
B) If he pulls at an angle as shown, what is the new torque?


## Principle of moments

The principle of moments states that for a body to be in equilibrium:
The sum of the external torques on a rigid object must be equal to zero


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\mathrm{F}_{1} \mathrm{~d}_{1}=\mathrm{F}_{2} \mathrm{~d}_{2}+\mathrm{F}_{3} \mathrm{~d}_{3}
$$

## Example 2. Family on seesaw

A young girl wants to sit still with her mother and father on a seesaw. Her father, 70 kg , sits only on one side 2.5 m from the pivot. On the other side, her mother, 50 kg , sits 3 m from the pivot. The girl sits on the same side as her mother. At what distance should the girl, who weighs 20 kg , sit from her mother?

## Example 3. Equating moments

A hinged trap-door of mass 15 kg and length 1.0 m is to be opened by applying a force $F$ at an angle of $45^{\circ}$.

Find F.


## Example 4

Find the moment of $F$ about $X$ in the diagram shown.


Hint: redraw the diagram so that the line of action of $F$ is clear.

## The vector product (cross product)

From examples 4 and 1, we can see that we might write a general formula for torque:
torque $=F \times r \sin \theta$ where $r$ is the magnitude of the displacement vector from the pivot to the application of $F$, and $\theta$ is the angle between $F$ and $r$.

## Example 4 redrawn.



Torque would then be: $\tau=|\vec{F}||\vec{r}| \sin \theta$

