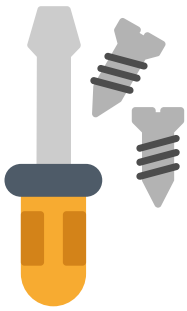
Rotational Force – GCSE Physics

CONTENTS:

1. Introduction

- **Rotational force** is the force that causes an object to rotate around a point or axis (**pivot point**) instead of moving in a straight line.
- This force is also called:
  - **Moment**
  - **Torque**
- **Rotational force** plays a crucial role in daily life and machines because it helps us turn, rotate, or twist objects using force applied at a distance from the axis.
- **Daily-life example:**

Opening or closing a door



Turning a screwdriver to fix screws

Seesaw movement

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2. What is Moment?

- A Moment **(in physics**) refers to the rotational effect produced by a force acting at a distance from a pivot point (axis of rotation).
- It is essentially a turning force that causes an object to rotate.
- Moment is another name for rotational force.

Moment Formula:

$$M = F \times d$$

Where:

- M = Moment in - **Nm**
- F = Force applied in - **N**
- d = Perpendicular distance from the pivot in - **m**

Example: A student applies a force of 20 N at the end of a spanner to loosen a nut. The distance from the nut to the point where the force is applied is 0.3 m. Calculate the moment (**rotational force**) about the nut.

Solution:

Given:
- F = 20N
- d = 0.3m

Using formula,

$$M = F \times d$$

$$M = 20N \times 0.3m$$

$$M = 6Nm$$

The moment about the nut is 6 Nm.

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3. How is Moment related to Torque?

- Moment tells us how strong the turning effect of a force is where **torque** is a special type of moment that not only makes something turn but also causes it to spin faster or slower (rotational acceleration) around an axis.
- **Torque** is another name for **moment;** both mean the turning effect of a force about a point.
- Torque is a specific term for the turning effect around the axis of rotation, especially used in mechanics, engines, and rotational systems.
- **Example: When you push a door to open it, you are using moment and torque together:** Moment explains how your push causes the door to rotate around its hinges and torque explains how strong that rotation will be.

Formula for both:

- **When the force is perpendicular to the pivot point:**

$$\text{Moment}(M) = F \times d$$

Where:

- F = Force applied in - **N**
- d = Perpendicular distance from the pivot in - **m**

- **When the force is at any angle or not perpendicular:**

$$\text{Moment}(M) = r \times F \times \sin\theta$$

Where:

- F = Force
- r = Distance from axis to point where force is applied.
- θ = Angle between F and r.

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4. How to calculate Rotational force?

- Calculation for rotation in terms of moment involves finding how much a force causes an object to turn around a point or pivot.
- To calculate moment in physics, we follow these simple steps:

Step#1: Identify the given values.

Step#2: Apply the formula and plug in the values.

Step#3: Calculate the moment.

Example: A force of 12 N is applied perpendicularly at a distance of 0.4 m from the hinge of a gate. Calculate the moment..

Solution:

Step#1: Identify the given values.

Given:

- **F** = 12N
- **d** = 0.4m

Step#2: Apply the formula and plug in the values.

The formula for moment is:

$$M = F \times d$$

Now plug in the values:

$$M = 12N \times 0.4m$$

Step#3: Calculate the moment.

$$M = 4.8\ Nm$$

The moment is **4.8 Nm** in the anticlockwise direction.

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5. Solved Examples

Problem1: A flagpole painter applies a force of 150 N perpendicularly on a brush attached to a rope that is tied 250 cm from the base of the flagpole to rotate and clean it. Calculate the moment about the base of the flagpole.

Solution:

Step#1: Identify the given values.

Given:

- **F** = 150N
- **d** = 250cm

Step#2: Apply the formula and plug in the values.

Convert **cm** to **m**:

$$250\text{cm} = \frac{250}{100} = 2.5\text{m}$$

The formula for moment is:

$$M = F \times d$$

Now plug in the values:

$$M = 150\text{N} \times 2.5\text{m}$$

Step#3: Calculate the moment.

$$M = 375\ \text{Nm}$$

The moment about the base of the flagpole is **375 Nm** in the anticlockwise direction.

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Problem2: A shopkeeper pushes down on the handle of a heavy shop shutter with a force of 400 N perpendicular to it, producing a moment of 800 Nm about the hinge. Find the distance from the hinge where the force is applied.

Solution:

Step#1: Identify the given values.

Given:

- F = 400N
- M = 800Nm

Step#2: Rearrange the formula and plug in the values.

The formula for moment is:

$$M = F \times d$$

Rearranged it:

$$d = \frac{M}{F}$$

Now plug in the values:

$$d = \frac{800Nm}{400N}$$

Step#3: Calculate the moment.

$$d = 2$$

The perpendicular distance is 2 meters.

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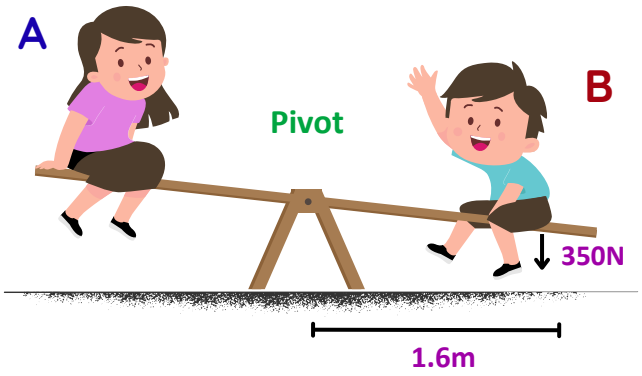
Problem3: Child B weighs 350 N and sits 1.6 m from the pivot on a balanced seesaw. Calculate the moment of child B about the pivot. Give your answer in newton-metres (**Nm**).



Solution:

Step#1: Identify the given values.

Given:

- **F** = 350N
- **d** = 1.6m

Step#2: Apply the formula and plug in the values.

The formula for moment is:

$$M = F \times d$$

Now plug in the values:

$$M = 350N \times 1.6m$$

Step#3: Calculate the moment.

$$M = 560\ Nm$$

The moment is **560 Nm.**

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6. FAQs

1. What is rotational force?

Rotational force (torque or moment) is the tendency of a force to cause an object to rotate around a point or axis.

2. Is torque the same as moment?

Yes, both measure rotational effect of a force.

3. What is the formula for moment?

Formula for moment:

$$M = F \times d$$

4. What are the units of moment?

Newton-meter (**Nm**).

5. How does the direction of force affect rotation?

- If the force causes clockwise rotation - moment is negative.
- If it causes anticlockwise rotation - moment is positive.

6. What happens if the distance from the pivot increases?

The moment increases, making it easier to rotate heavy objects.

7. Give a real-life example of rotational force.

Opening a door, using a spanner, turning a steering wheel, or pushing a swing are daily examples of rotational force.