

انسباير Rotational Dynamics



تم تحميل هذا الملف من موقع المناهج الإماراتية

موقع المناهج ← المناهج الإماراتية ← الصف الحادي عشر المتقدم ← فيزياء ← الفصل الأول ← ملفات متنوعة ← الملف

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ملفات اكتب للمعلم اكتب للطالب ا اختبارات الكترونية ا اختبارات ا حلول ا عروض بوربوينت ا أوراق عمل
منهج انجليزي ا ملخصات وتقارير ا مذكرات وبنوك ا الامتحان النهائي ا للمدرس

المزيد من مادة
فيزياء:

إعداد: عبدالرحمن عصام عيد

التواصل الاجتماعي بحسب الصف الحادي عشر المتقدم



صفحة المناهج
الإماراتية على
فيسبوك

الرياضيات

اللغة الانجليزية

اللغة العربية

التربية الاسلامية

المواد على تلغرام

المزيد من الملفات بحسب الصف الحادي عشر المتقدم والمادة فيزياء في الفصل الأول

انسباير Describing Rotational Motion

1

انسباير Rotational Dynamics

2

الحركة الدائرية

3

اختبار مطابق لمخرجات الهيكل الوزاري منهج انسباير

4

حل مراجعة شاملة وفق الهيكل الوزاري منهج انسباير

5



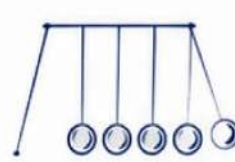
أينشتاين العرب
Einstein of the Arabs

مصدرك الأول

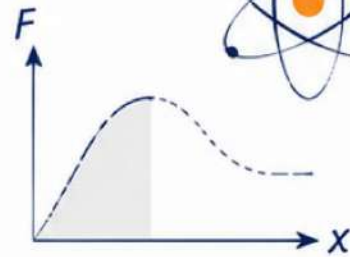
— للعلامة —

الكاملة

في الفيزياء



$$E = mc^2$$



استاذ

عبدالرحمن عصام عيد



معك خطوة بخطوة
نحو التفوق والتميز



0509886279



Einsteinabdo

Einstein_AE



Lesson 2 Rotational Dynamics part 1

Force and Angular Velocity

Angular velocity describes how fast an object rotates.

When a **force** acts on an object, it can cause the object to **rotate about an axis** and increase its angular velocity.

Example: Toy Top

If you wrap a string around a toy top and pull hard, you can make the top **spin rapidly**.

The force of the string acts at the **outer edge of the top** and in a direction that causes rotation.

How does the force cause rotation?

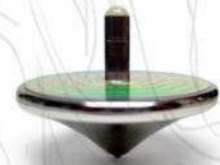
A force produces a rotational effect when it acts at a **distance from the axis of rotation** and in a direction that causes the object to rotate.

The **farther the force is applied from the axis**, the greater the rotational effect.

Example: Spinning a Top

When you pull the string wrapped around a toy top:

- The force acts **tangentially** to the circular path.
- The force causes the top to **rotate**.
- It increases the top's **angular velocity**.
- Applying the force farther from the axis produces a **greater rotational effect**.



Key Idea: A force can change the angular velocity of an object when it is applied at a distance from the axis of rotation in a direction that causes rotation.

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Extended Objects & How Force Affects Rotation

An **extended object** is an object that has a **definite shape and size**.

In the case of an extended object, a force can change its **angular velocity** when the force is applied in a specific way.

Key Idea

The effect of a force on the rotation of an object depends on:

- **Magnitude of the force**
- **Distance from the axis of rotation**
- **Direction of the force**

3. How Does Force Affect Rotation?

How can you exert a force to open a door easily?

To get the **most effect from the least force**, you should exert the force as far from the **axis of rotation** as possible.

Example: Opening a Door

The door rotates about an axis that is an imaginary vertical line through the **hinges**.

The doorknob is near the outer edge of the door.

To open the door effectively, apply the force on the doorknob at **right angles to the door**.

4. Factors Affecting Rotation

The change in angular velocity depends on:

① Magnitude of the Force

The **magnitude of the force** affects the rotational effect.

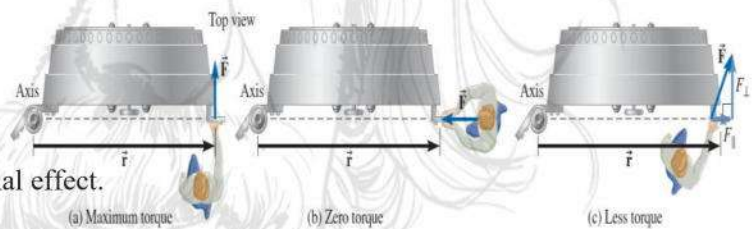
② Distance from the Axis

The **farther the force is applied from the axis of rotation**, the greater the rotational effect.

③ Direction of the Force

The direction in which the force is applied affects the rotational effect.

A force applied **perpendicular to the door** produces the greatest effect.



5. Effect of the Force

Situation	Effect
Force applied in an ineffective direction	No Effect
Force applied at an angle	Some Effect
Force applied farthest from the hinges and perpendicular to the door	Maximum Effect

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Zero Torque & the Lever Arm — Practice

Important Rule

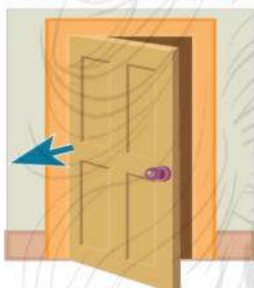
To get the most effect from the least force, apply the force as far from the axis of rotation as possible and at an angle perpendicular to the object.

Door Example

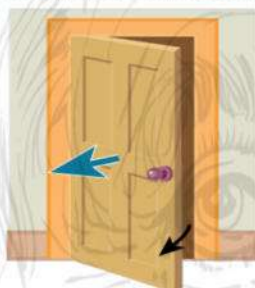
- Axis of rotation → Hinges
- Point of application → Doorknob
- Best direction → Perpendicular to the door
- Result → Maximum effect



No effect



Some effect



Maximum effect



No effect



Some effect



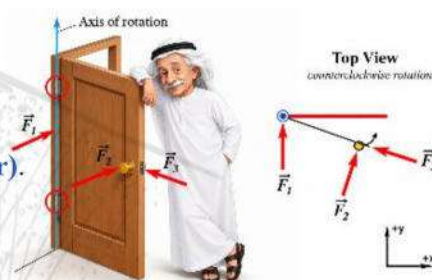
Maximum effect

Complete the given sentences:

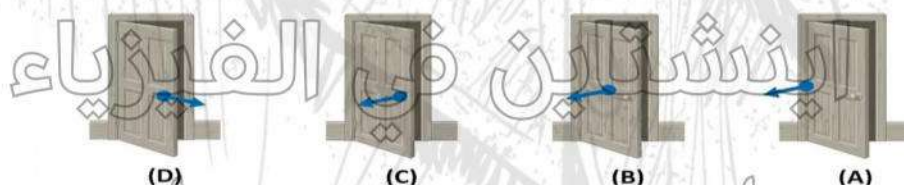
F_1 will **not** cause rotation because it is applied **directly at the axis of rotation**.

F_2 will **not** cause rotation because it is **parallel to the lever arm (along the door)**.

F_3 will **cause** rotation because it is **perpendicular to the lever arm**.

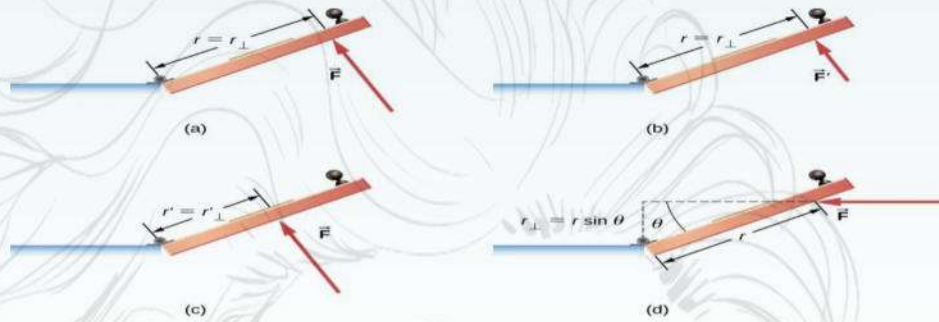


1. Which of the shapes shown (A–D) produces **the least torque** when the same force is applied at the point indicated on each door?

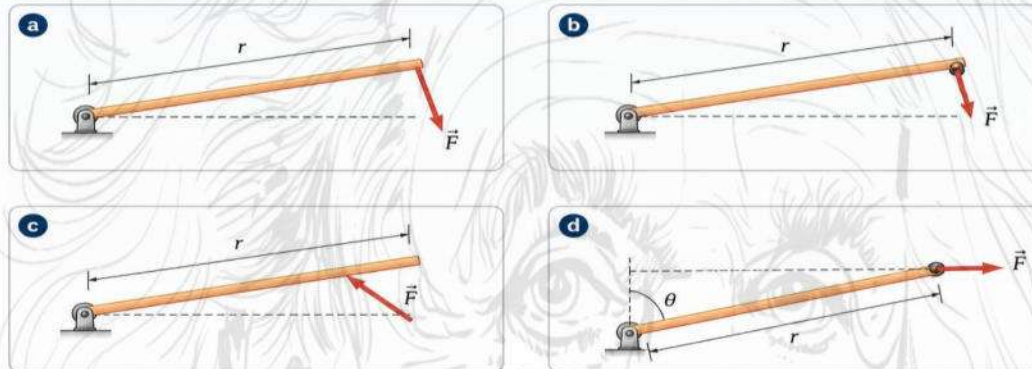


Ⓐ (C) & (D) Ⓑ (A) & (C) Ⓒ (B) & (C) Ⓓ (A) & (D)

Opening a Door — The door that has **the greatest** torque on is:

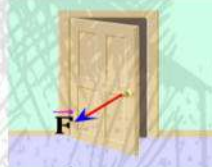
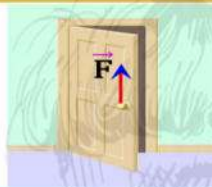


Opening a Door — The door that has **the greatest** torque on is:



When a person opens a door, a force $\vec{F}$ is applied to the door producing a torque (τ) about the hinges.

Which of the following situations results in **zero torque** and therefore does not help open the door?



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2. Based on the illustration, why does the applied force produce **no rotational effect** on the top-left door?

- Ⓐ The force is applied parallel to the lever arm (along the door).
- Ⓑ The force is applied perpendicular to the lever arm.
- Ⓒ The force is applied perpendicular to the axis of rotation.
- Ⓓ The force is applied directly at the axis of rotation.

3. Which of the following forces produces **zero torque** on an object?

- Ⓐ A force applied perpendicular to the lever arm.
- Ⓑ A force applied far from the axis of rotation.
- Ⓒ A force whose line of action passes through the axis of rotation.
- Ⓓ A force applied perpendicularly at the handle.

4. A force F is applied to a door in six different ways, as shown.

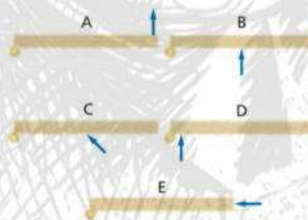
For which pair of positions is the **torque about the hinge** equal to **zero**?



- Ⓐ 1 & 4
- Ⓑ 2 & 3
- Ⓒ 5 & 6
- Ⓓ 2 & 5

5. The figure shows five doors subjected to forces of equal magnitude.

Which of the following correctly ranks the **torques** about the hinge from **least to greatest**?



- Ⓐ $E < D < C < B < A$
- Ⓑ $E < C < D < B < A$
- Ⓒ $C < D < E < B < A$
- Ⓓ $E < D < B < A < C$

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Opening a Door

✦✦ What is the easiest way to open a door?

Torque depends on both the applied force and the distance from the axis of rotation. The farther the force is applied from the hinge, the greater the torque produced, and the easier it is to rotate the door.



Identify the Axis of Rotation

The axis of rotation in a door is the hinges.

Axis of rotation in the door is: _____

Your Task

Look at the door illustration below.
Mark the point where applying force would make the door open most easily.

Hint:

Choose the point farthest from the hinges.

The maximum or zero

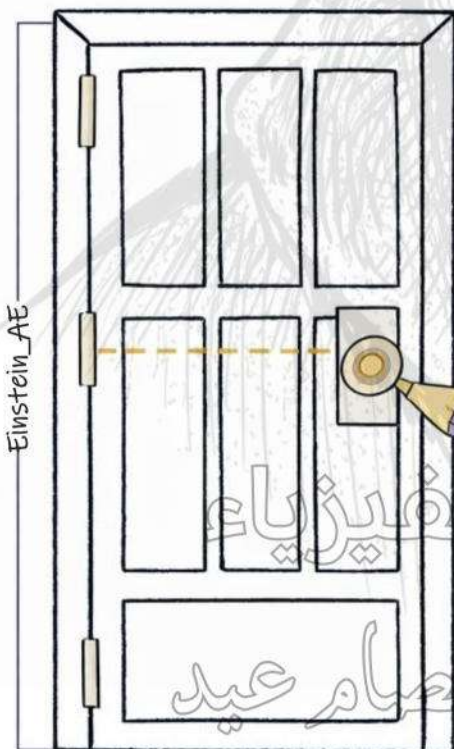
- Force near hinges
- Force at the edge (handle)

Conclusion

Maximum torque occurs when:

Distance from axis is maximum

Force is applied perpendicular to the door



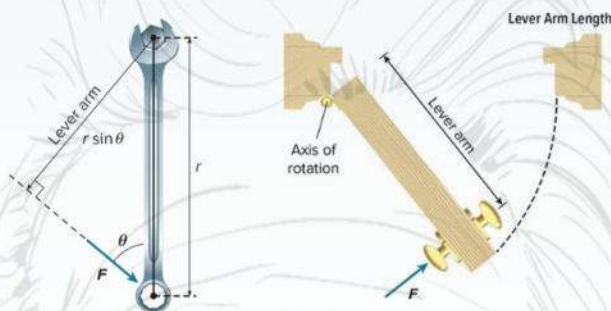
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Torque — Definition, Formula, and Direction

3. Lever Arm (r)

The lever arm is the **perpendicular distance** from the axis of rotation to the line of action of the force.

Important points:



- If the force is **perpendicular**, the lever arm equals the distance from axis to where force is applied.
- If the force is at an angle, the lever arm is:

$$L = r \sin \theta$$

where: L = distance from the axis to the point of force ; θ = angle between the force and the lever arm

Why lever arm matters: A larger lever arm produces a greater rotational effect for the same force.

4. Torque (τ)

Torque is a measure of the ability of a force to rotate an object about an axis.

Definition: Torque is the measure of how much a force causes rotation.

Torque causes rotation. Depends on: (a) the magnitude of the force, (b) the direction of the force, (c) the lever arm.

Torque Formula

$$\tau = F \times L$$

If the force is applied at an angle:

$$\tau = F r \sin \theta$$

Units

- Force $\rightarrow$ newtons (N)
- Distance $\rightarrow$ meters (m)
- Torque $\rightarrow$ newton-meters (N·m)

Perpendicular force $\rightarrow$ angle = 90° . Parallel force $\rightarrow$ angle = 0° .

Important notes

- **Greatest torque** occurs when the force is **perpendicular** to the lever arm: $\theta = 90^\circ \Rightarrow \tau = Fr$
- **Greater lever arm $\rightarrow$ greater torque**

Axis of Rotation: To calculate torque correctly, **an axis of rotation must be specified.**

Direction of Torque

Torque, like displacement and force, is a **vector quantity**.

- **Counterclockwise rotation $\rightarrow$ Positive torque**
- **Clockwise rotation $\rightarrow$ Negative torque**

Note: A larger torque leads to a greater change in angular velocity.

Worked Example: Bolt and Wrench

A bolt on a car engine must be tightened with a torque of $35 \text{ N}\cdot\text{m}$. You use a **25-cm long wrench** and pull the end of the wrench at an angle of 60.0° to the handle.

Find: (1) The **length of the lever arm**. (2) The **force needed**.

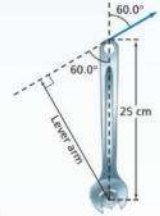
Solution

1. Lever arm

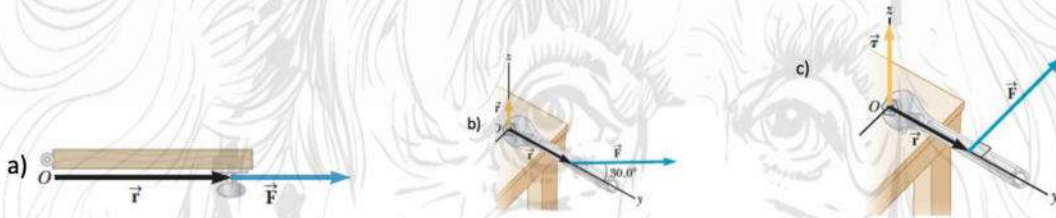
$$L = r \sin \theta = (0.25 \text{ m}) \sin(60.0^\circ) \approx 0.217 \text{ m}$$

2. Force needed

$$\tau = F L \Rightarrow F = \frac{\tau}{L} = \frac{35}{0.217} \approx 161 \text{ N}$$

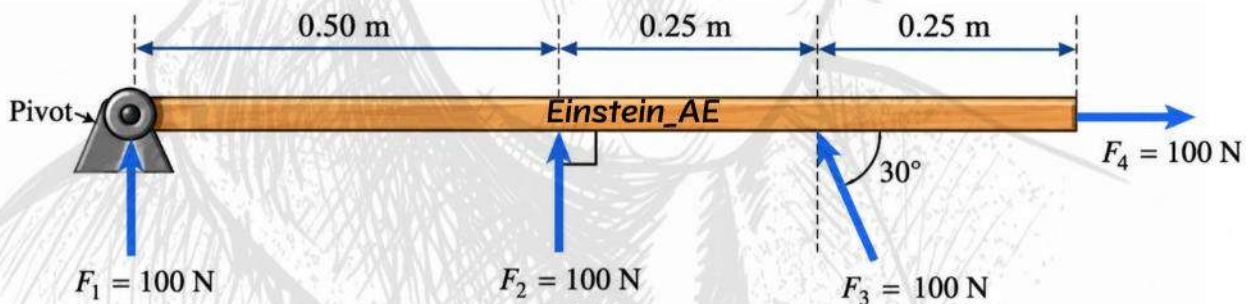


Calculate the torque in each of the following cases if the wrench length is $r = 110 \text{ cm}$ and the applied force is $F = 50 \text{ N}$. For each diagram:



A uniform rod is pivoted at the left end. Four forces act on the rod as shown in the figure. Each force has a magnitude of 100 N . The forces act at 0.5 m , 0.75 m , and 1.0 m from the pivot.

Determine the torque produced by each of the following forces (F_1 , F_2 , F_3 , F_4).



1. Force F_1 acting.....
2. Force F_2 acting.....
3. Force F_3 acting.....
4. Force F_4 acting.....

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Worked Examples — Torque Calculations

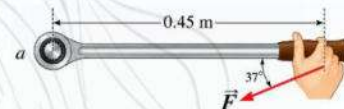
1. If the door below is 0.90 m wide and you exert a force of 2.0 N, what is the magnitude of the resulting torque?

- (a) 2.9 N·m (b) 1.8 N·m (c) 0.45 N·m (d) 0.40 N·m

2. A wrench of length 0.45 m is used to remove a bolt and is free to rotate about point a. An external force of 85 N is applied to the wrench at an angle of 37° , as shown in the figure.

what are the magnitude and direction of the torque applied to the wrench?

- (a) +51.15 N·m (b) -23.02 N·m (c) -38.25 N·m (d) +23.02 N·m



3. A bolt on a car engine must be tightened with a torque of 35 N·m.

A 25-cm wrench is used, and the force is applied at an angle of 60° to the wrench handle.

What magnitude of force must be exerted?

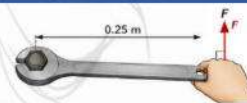
- (a) 81 N (b) 108 N (c) 162 N (d) 280 N



4. A wrench is used to tighten a bolt with a torque of 40 N·m.

The force is applied perpendicular to the 0.25 m wrench. What force is required?

- (a) 80 N (b) 120 N (c) 160 N (d) 200 N



5. A torque of 55.0 N·m is required to turn a bolt. The maximum force that can be exerted is 135 N.

What is the minimum lever arm length required?

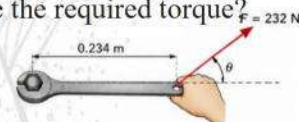
- (a) 0.22 m (b) 0.41 m (c) 0.55 m (d) 0.74 m



6. A mechanic uses a 0.234 m wrench to apply a force of 232 N. A torque of 32.4 N·m is required.

What is the smallest angle between the force and the wrench that will produce the required torque?

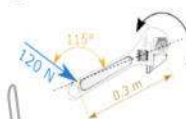
- (a) 30° (b) 37°
(c) 45° (d) 60°



7. A spanner is used to loosen a bolt, as shown. A force of 120 N is applied at an angle of 115° to the spanner handle. The distance from the pivot to the point of application is 0.30 m.

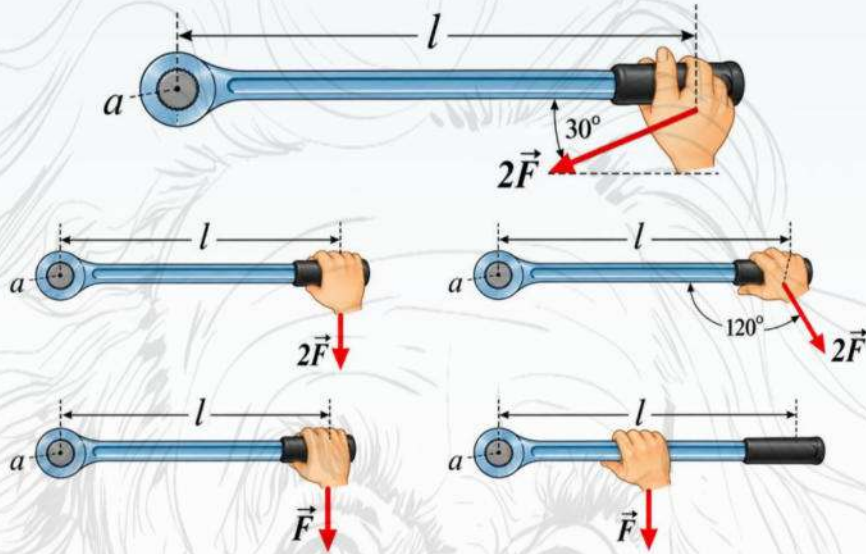
What is the torque exerted on the bolt?

- (a) 32.6 N·m (b) 72.6 N·m (c) 44.8 N·m (d) 55.2 N·m



8. A wrench of length (l) is used to remove a bolt and is free to rotate about point (a). An external force ($2F$) is applied perpendicular to the wrench, as shown in the figure below.

Which of the following cases is the torque on the wrench equal to half the torque in the figure above?



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Net Torque from Multiple Forces

When **more than one force** acts on an object that can rotate about an axis, each force produces a **torque**. The **net torque** is the algebraic sum of all the torques, taking their **directions** into account.

Determine the Direction of Each Torque

A force can cause rotation in two directions:

- **Counterclockwise** — Usually taken as **positive**: $+\tau$
- **Clockwise** — Usually taken as **negative**: $-\tau$

Important: The positive and negative signs indicate the **direction of rotation**.

Find the Net Torque

Add all the torques algebraically:

$$\tau_{\text{net}} = \tau_1 + \tau_2 + \tau_3 + \dots$$

The Right-Hand Rule for Torque Sign ("Einstein's Rule")

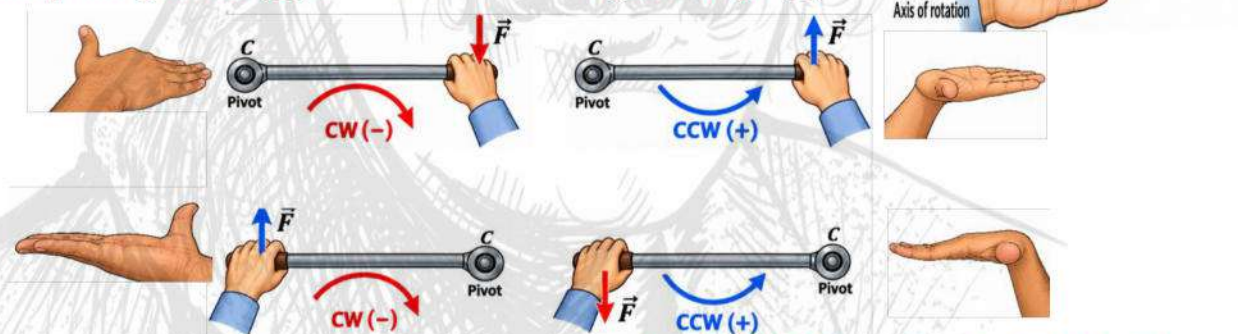
This hand rule helps determine the **sign of a torque** from the direction of the applied force.

Parts of the Hand

- **Wrist:** stays fixed at the **axis of rotation** (the pivot point) and does not move.
- **Palm:** extends along the **lever arm** and moves with the **direction of the force** (up or down).
- **Thumb:** points in the **direction of the torque and its sign**.

Thumb Rule (Sign and Rotation)

- ✓ **Thumb pointing outward** ($\odot$): counterclockwise rotation $\Rightarrow$ **positive torque** (+)
- ✓ **Thumb pointing inward** ($\otimes$): clockwise rotation $\Rightarrow$ **negative torque** (-)



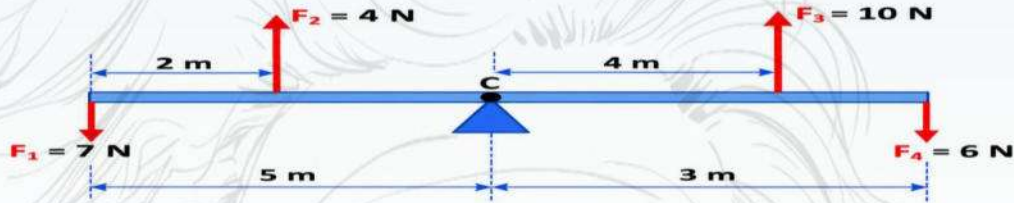
قاعدة اينشتاين العرب لتحديد إشارة العزم اليد اليمنى
توزيع أجزاء اليد

- الرسغ: يثبت عند محور الدوران (نقطة الارتكاز) ولا يتحرك.
- الكف: يمتد على ذراع القوة ويتحرك مع اتجاه القوة (لأعلى أو لأسفل)
- الإبهام: يشير إلى اتجاه العزم وإشارته قاعدة الإبهام (الإشارة والدوران)
- ✓ الإبهام للخارج: ($\odot$) دوران عكس عقارب الساعة $\leftarrow$ عزم موجب (+)
- ✓ الإبهام للداخل: ($\otimes$) دوران مع عقارب الساعة $\leftarrow$ عزم سالب (-)

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Worked Examples — Net Torque (Seesaws & Beams)

Application: A seesaw is pivoted at point C. Four vertical forces act on the seesaw as shown in the figure. Assume that the weight of the seesaw acts through the pivot point C and therefore produces no torque.



Calculate the **net torque** produced by all the forces about point C, and determine the **direction of rotation** of the seesaw.

Solution $\tau = F \times r$ (CCW = positive, CW = negative)

$F_1 = 7 \text{ N}$, $r_1 = 5 \text{ m}$

$$\tau_1 = (7)(5) = +35 \text{ N} \cdot \text{m}$$

$F_2 = 4 \text{ N}$, distance from C: $r_2 = 5 - 2 = 3 \text{ m}$

$$\tau_2 = (4)(3) = -12 \text{ N} \cdot \text{m}$$

$F_3 = 10 \text{ N}$, $r_3 = 4 \text{ m}$

$$\tau_3 = (10)(4) = +40 \text{ N} \cdot \text{m}$$

$F_4 = 6 \text{ N}$, $r_4 = 3 \text{ m}$

$$\tau_4 = (6)(3) = -18 \text{ N} \cdot \text{m}$$

Net torque

$$\tau_{\text{net}} = 35 - 12 + 40 - 18 = +45 \text{ N} \cdot \text{m}$$

Since the net torque is positive, the direction of rotation is **Counterclockwise (CCW)**.



A **2.00 m uniform beam** is subjected to three forces, as shown in the figure. The forces have magnitudes of **52.0 N**, **65.0 N**, and **56.0 N**, acting at the angles shown.

Determine the magnitude and direction of the net torque about:

(a) The center of mass, point C. (b) The left end, point P.

Solution Using $\tau = F r \sin \theta$

(a) Torque about the center of mass C

The 65 N force acts at the pivot C, so $\tau_{65} = 0$

$$\tau_{52} = (52)(1.00) \sin 60^\circ = +45.0 \text{ N} \cdot \text{m}$$

$$\tau_{56} = (56)(1.00) \sin 30^\circ = -28.0 \text{ N} \cdot \text{m}$$

$$\tau_{\text{net}} = 45.0 + (-28.0) = +17.0 \text{ N} \cdot \text{m} - \text{Counterclockwise (CCW)}$$

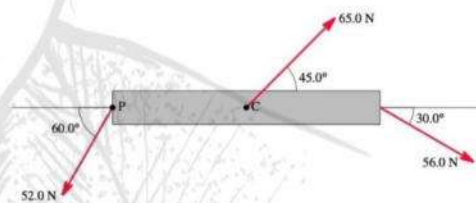
(b) Torque about point P

The 52 N force acts at P, so $\tau_{52} = 0$

$$\tau_{65} = (65)(1.00) \sin 45^\circ = +46.0 \text{ N} \cdot \text{m}$$

$$\tau_{56} = (56)(2.00) \sin 30^\circ = -56.0 \text{ N} \cdot \text{m}$$

$$\tau_{\text{net}} = 46.0 + (-56.0) = -10.0 \text{ N} \cdot \text{m} - \text{Clockwise (CW)}$$

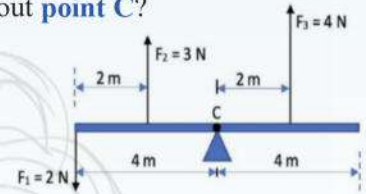


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1. The figure shows a **uniform seesaw** rotating about a **pivot at point C**. Three forces act on the seesaw as shown. What is the **net torque** and **direction** produced by the forces about **point C**?

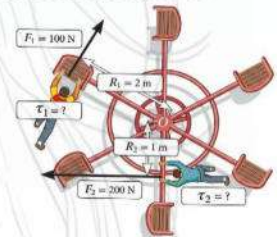
- Ⓐ $6 \text{ N}\cdot\text{m}$, clockwise Ⓑ $8 \text{ N}\cdot\text{m}$, counterclockwise
Ⓒ $10 \text{ N}\cdot\text{m}$, clockwise Ⓓ $12 \text{ N}\cdot\text{m}$, counterclockwise



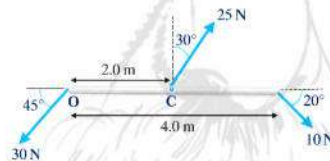
2. The figure shows two workers applying forces to a rotating **wheel-like device**.

The forces act **perpendicular to the radius**. What is the **net torque** on the system about the axis of rotation and what is the **direction of rotation**?

- Ⓐ $400 \text{ N}\cdot\text{m}$, clockwise
Ⓑ $200 \text{ N}\cdot\text{m}$, clockwise
Ⓒ $200 \text{ N}\cdot\text{m}$, counterclockwise
Ⓓ $400 \text{ N}\cdot\text{m}$, counterclockwise



3. A **rod of length 4.0 m** is acted upon by **three forces**, as shown.

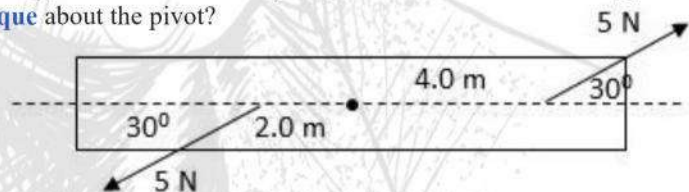


Determine the **net torque** on the rod about an axis passing through **point C** and perpendicular to the page.

- Ⓐ $15 \text{ N}\cdot\text{m}$ clockwise Ⓑ $22 \text{ N}\cdot\text{m}$ counterclockwise Ⓒ $30 \text{ N}\cdot\text{m}$ clockwise Ⓓ $37 \text{ N}\cdot\text{m}$ counterclockwise

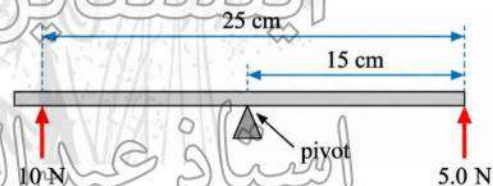
4. A rod is pivoted about its center. A **5 N** force is applied **4.0 m** from the pivot, and another **5 N** force is applied **2.0 m** from the pivot, as shown. What is the **total torque** about the pivot?

- Ⓐ $15 \text{ N}\cdot\text{m}$ clockwise
Ⓑ $15 \text{ N}\cdot\text{m}$ counterclockwise
Ⓒ $0 \text{ N}\cdot\text{m}$
Ⓓ $10 \text{ N}\cdot\text{m}$ clockwise



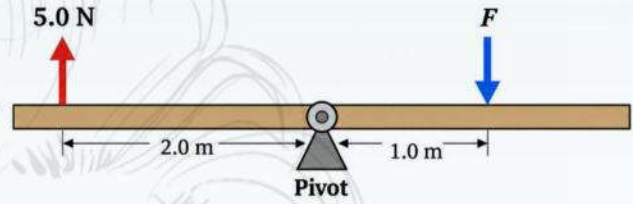
5. A beam is pivoted at its **centre of mass**. It is acted upon by two forces, **10 N** and **5.0 N**. The **10 N** force acts **25 cm** from the pivot, while the **5.0 N** force acts **15 cm** from the pivot. What is the **torque about the axis**?

- Ⓐ $25 \text{ N}\cdot\text{cm}$ counterclockwise
Ⓑ $25 \text{ N}\cdot\text{cm}$ clockwise
Ⓒ $175 \text{ N}\cdot\text{cm}$ counterclockwise
Ⓓ $175 \text{ N}\cdot\text{cm}$ clockwise



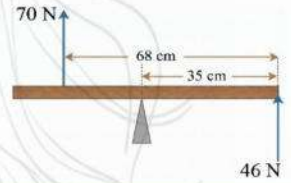
6. A beam is pivoted at its center. Two vertical forces act on the beam as shown. The net torque about the pivot is $25 \text{ N} \cdot \text{m}$ clockwise. The 5.0 N force acts 2.0 m from the pivot, while the unknown force F acts 1.0 m from the pivot. Determine the magnitude of the unknown force F .

- (a) 10 N
(b) 15 N
(c) 20 N
(d) 30 N



7. A beam is pivoted at its center of mass. Two forces of 70 N and 46 N act on the beam what is the net (resultant) torque about the pivot?

- (a) $-7.0 \text{ N} \cdot \text{m}$ Clockwise (b) $7.0 \text{ N} \cdot \text{m}$ Counter-clockwise
(c) $-23.1 \text{ N} \cdot \text{m}$ Clockwise (d) $-16.1 \text{ N} \cdot \text{m}$ Clockwise



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LESSON 2 Rotational Dynamics

Rotational Equilibrium

If equal torques act in **opposite directions**, then the **net torque is zero**.

This means the object does **not rotate** and is in **rotational equilibrium**.

2. Equilibrium Condition

A body is in **rotational equilibrium** when the **net torque about the axis of rotation is zero** $\Sigma \tau = 0$.

For example: $\tau_{CCW} = \tau_{CW} \Rightarrow \tau_{net} = 0$

Result: Equal torques in opposite directions cancel each other, resulting in zero net torque.

3. Two Pencils and a Coin

This simple experiment demonstrates how **torques can cancel each other**.

You will need:

- Two pencils
- One coin
- Transparent tape

Procedure

- Tape the **coin to one end of a pencil**.
- Place the second pencil underneath the first one.
- Balance the first pencil on the second pencil.

The coin has **weight**, so it produces a torque about the **balancing point (pivot)**.

4. Torque Produced by the Coin

$$\tau = rF \text{ (or } \tau = rW, \text{ since the force is the coin's weight)}$$

- τ = Torque
- r = Distance from the pivot point
- W = Weight of the coin

Note: The farther the coin is from the pivot, the greater the torque it produces.

5. How Do Torques Cancel?

If **equal forces** act at **equal distances** from the pivot but produce **opposite rotational directions**, the torques cancel.

For example: $\tau_1 = \tau_2$, but they act in opposite directions — one torque is **Clockwise (-)** and one is **Counterclockwise (+)**.

$$\tau_{net} = \tau_{CCW} + \tau_{CW} = (+\tau) + (-\tau) = 0$$

Result: The pencil **does not rotate** ($\tau_{net} = 0$). Therefore, the pencil remains **balanced**.

6. How to Create Net Torque

To make the pencil **rotate**, you must disturb the balance by changing one or more factors that affect torque.

① Add Extra Weight

Place an **additional coin** on one side. This increases the **force (weight)** and produces a **larger torque**.

② Change the Lever Arm

Move the coin **farther from the pivot point**. Increasing the distance **increases the torque** ($\tau \propto r$).

③ Shift the Balance Point

Move the **pivot point** so that the distances on the two sides become unequal. Different distances produce **different torques**.

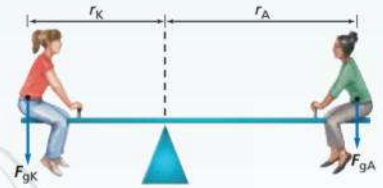
Result: Any of these changes causes the object to **rotate**.



Equilibrium & Balance Problems

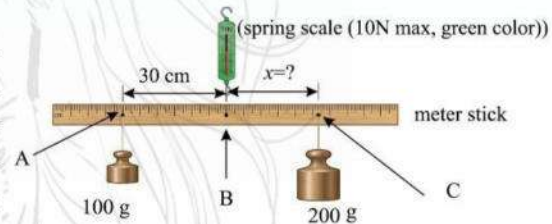
Kariann (56 kg) and Aysha (43 kg) want to balance on a 1.75-m-long seesaw.

Where should they place the pivot point?



A meter stick is suspended horizontally from a spring scale as shown in the diagram. A **100 g** mass hangs **30 cm** to the left of the suspension point **B**, and a **200 g** mass hangs on the right side of the stick at an unknown distance **x** from point **B**. The system is in **rotational equilibrium** (no rotation).

What is the value of the distance x that keeps the meter stick balanced?



Mohammad, whose weight is **270 N**, sits **1.50 m** from the center of a seesaw. Salem, whose weight is **320 N**, sits on the opposite side.

(a) Calculate the **torque** produced by Mohammad.

(b) Calculate how **far** from the center Salem should sit in order to **balance Mohammad on the seesaw**.

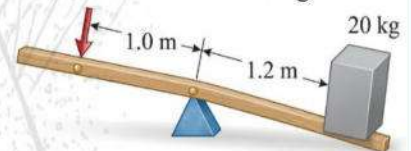


1. Fatimah ($m=56$ kg) and Aisha ($m=43$ kg) want to play on a seesaw while keeping the system balanced. Aisha sits at a distance of **1.5 m** from the pivot. At what **distance** from the pivot should Fatimah sit in order to balance the seesaw?

- Ⓐ 1.5 m Ⓑ 0.85 m Ⓒ 1.0 m Ⓓ 1.15 m

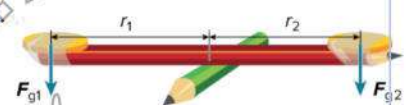
2. In the adjacent figure, the rod has a mass of **15 kg** and is free to rotate about the pivot located at its midpoint. A box of mass **30 kg** is placed at point **a** on top of the rod, at the distances shown in the figure.

- Ⓐ A. It remains horizontal Ⓑ B. It rotates to the left and settles tilted
Ⓒ C. It remains in its original position without rotating
Ⓓ D. It rotates to the left and then returns to settle tilted toward the right



3. In the figure below, the **red pencil** is balanced on top of the **green pencil**.

How can you make the red pencil -rotate?



- Ⓐ Add a second coin on top of one of the coins Ⓑ Keep the distance between the two coins as it is
Ⓒ Add a second coin on top of each coin on both sides Ⓓ Remove the green pencil

4. The figure shows **Mohammad** and his sister **Laila** sitting on a seesaw and trying to balance it. Which of the following actions will lead to **equilibrium** on the seesaw?

- Ⓐ Laila moves closer to Mohammad
- Ⓑ Mohammad moves closer to Laila
- Ⓒ Mohammad and Laila both move toward each other by the same distance
- Ⓓ Mohammad and Laila both move away from each other by the same distance

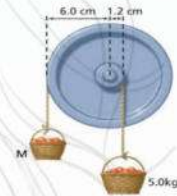


5. A system consists of **two pulleys** fixed together and rotating about a common axis passing through their centers. Two buckets are hung from the pulleys, and the system is in **equilibrium** as shown in the figure. The right bucket has a mass of **5.0 kg**, and it hangs at a radius of **1.2 cm**.

The left bucket with unknown mass **M** hangs at a radius of **6.0 cm**.

What is the value of the mass **M**?

- Ⓐ 25 kg
- Ⓑ 5.0 kg
- Ⓒ 2.5 kg
- Ⓓ 1.0 kg



6. Two fruit baskets are suspended from two ropes as shown in the diagram. The left basket of mass **m** hangs at a horizontal distance of **0.28 m** from the support. The right basket has a mass of **0.8 kg** and hangs at a distance of **0.16 m** from the support. What is the mass that makes the baskets balance without rotation?



- Ⓐ 1.40 kg
- Ⓑ 0.60 kg
- Ⓒ 0.46 kg
- Ⓓ 1.26 kg

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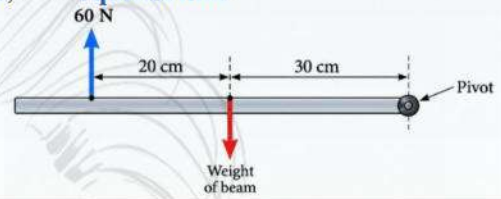
10. Practice — Beams, Pulleys, and Torque MCQs

1. A **uniform horizontal beam**, pivoted at its **right-hand end**, is in **equilibrium**.

A **60 N** force acts vertically upwards on the beam as shown.

What is the weight of the beam?

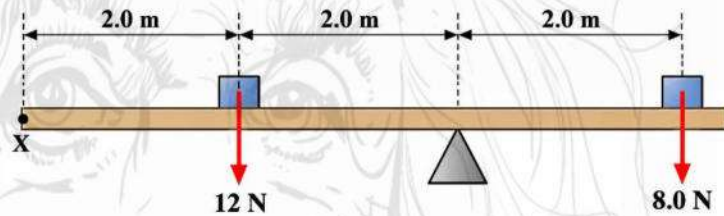
- (a) 36 N (b) 40 N (c) 90 N (d) 100 N



2. A **uniform plank** is pivoted at its **midpoint**. Two weights are placed on the plank, one on each side of the pivot, as shown. A **vertical force** is applied at point **X** to balance the plank.

What are the magnitude and direction of this force?

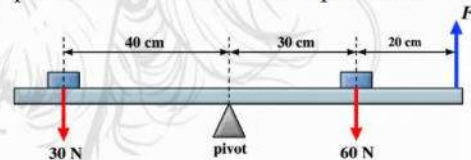
	Magnitude / N	Direction
(a)	2.0	Downwards
(b)	2.0	Upwards
(c)	4.0	Downwards
(d)	4.0	Upwards



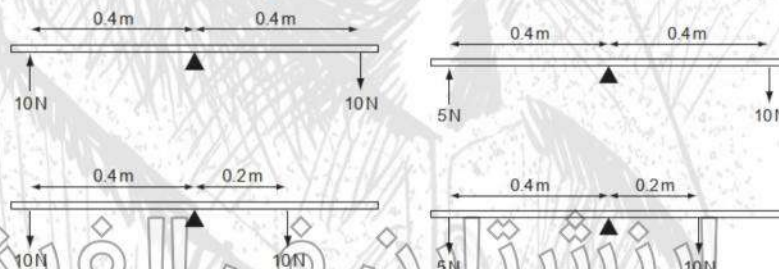
3. A **uniform beam** is pivoted at its **centre**. Two weights are placed on the beam at the positions shown. The beam is balanced by an **upward force F**.

What is the magnitude of F?

- (a) 6 N (b) 12 N (c) 30 N (d) 60 N



4. Forces are applied to a **uniform beam pivoted at its centre**.



Which beam is balanced?

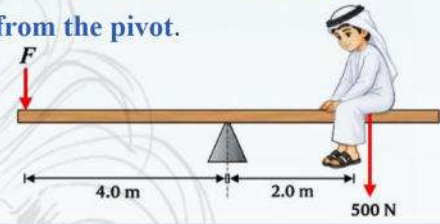
- (a) Beam A (b) Beam B (c) Beam C (d) Beam D

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5. The diagram shows a boy of **weight 500 N** sitting on a see-saw. He sits **2.0 m** from the pivot. A force **F** is applied at the other end of the see-saw, which is **4.0 m** from the pivot.

What is the force F needed to balance the see-saw?

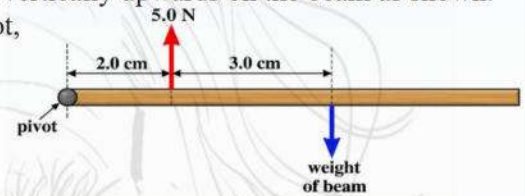
- (a) 250 N (b) 750 N (c) 1000 N (d) 3000 N



6. A **uniform beam** is pivoted at one end. A force of **5.0 N** acts vertically upwards on the beam as shown. The beam is in **equilibrium**. The force acts **2.0 cm** from the pivot, while the weight of the beam acts **5.0 cm** from the pivot.

What is the weight of the beam?

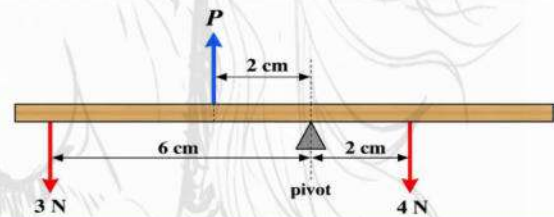
- (a) 2.0 N (b) 3.0 N (c) 3.3 N (d) 5.0 N



7. The diagram shows a **uniform balanced beam**, pivoted about its **centre**. A force **P** acts vertically upwards. A **3 N** force acts **6 cm** from the pivot, and a **4 N** force acts **2 cm** from the pivot.

What is the value of force P?

- (a) 5 N
(b) 7 N
(c) 10 N
(d) 13 N



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