

Einstein_AE PHYSICS END OF TERM 3 COVERAGE



تم تحميل هذا الملف من موقع المناهج الإماراتية

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

تاريخ إضافة الملف على موقع المناهج: 2026-05-25 12:26:30

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

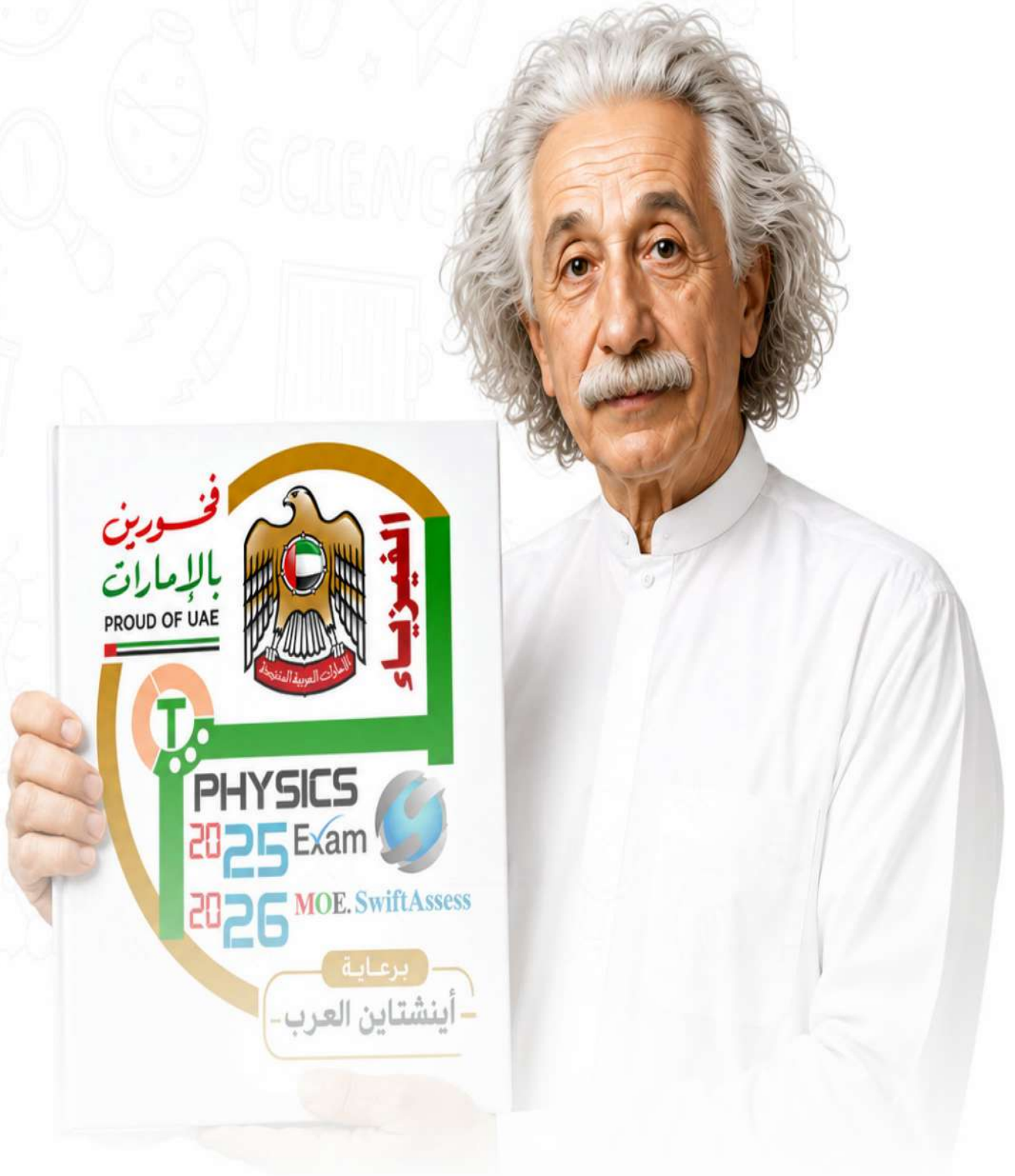
المواد على تلغرام

المزيد من الملفات بحسب الصف الحادي عشر المتقدم والمادة فيزياء في

Einstein_AE

PHYSICS

END OF TERM 3 COVERAGE (2025–2026)



اينشتاين العرب

مراجعة الهيكل الوزاري
END OF TERM 3 COVERAGE

الهيكل الوزاري

شرح واضح للمخرجات



شرح تفصيلي ومنظم لكل مخرج من مخرجات المنهج
بلغة سهلة وأمثلة تطبيقية توضح الفهم

تدريبات شاملة



تدريبات متنوعة تغطي
جميع أنواع الأسئلة
على كل مخرج

تغطية الهيكل



كل مخرج في مكانه
وفقاً للمواصفات الرسمية
للهيكل

أسئلة وزارية سابقة



تجميع لأهم الأسئلة
الوزارية السابقة
مع الحل النموذجي

اختبارات تجريبية



نماذج اختبارات شاملة
على الهيكل بالكامل
تحاكي الامتحان الحقيقي

Mr. Abdulrahman Esam Eid

استاذ عبدالرحمن عصام عيد

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هذه الملازم متاحة حصرياً للمشتركين

Learning Outcome 1

Define a **radian** and convert **degrees to radians** and vice versa.

Identify that **counterclockwise motion is positive** and **clockwise motion is negative**.

Measuring Revolution

A revolution can be measured in:

- **Degrees** $\rightarrow 360^\circ = 1 \text{ rev}$
- **Radians** $\rightarrow 2\pi \text{ rad} = 1 \text{ rev}$

Units of Angular Displacement

Angular displacement can be expressed in three units:

- **Radian (rad)** $\rightarrow$ SI unit
- **Degree ($^\circ$)** $\rightarrow$ one complete turn $= 360^\circ$
- **Revolution (rev)** $\rightarrow$ one complete rotation

What is a Radian?

A **radian** is the angle formed when the **arc length equals the radius** of a circle.

One complete revolution equals:

$$360^\circ = 2\pi \text{ rad}$$

The radian is abbreviated as:

rad

Positive and Negative Rotation

- **Counterclockwise rotation** $\rightarrow$ Positive (+)
- **Clockwise rotation** $\rightarrow$ Negative (-)

Example:

$+\pi \text{ rad} \rightarrow$ Counterclockwise

$-\pi \text{ rad} \rightarrow$ Clockwise

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Radian–Degree ConversionConvert from **radians to degrees**:

$$\text{degree} = \text{radian} \times \frac{180^\circ}{\pi}$$

Convert from **degrees to radians**:

$$\text{radian} = \text{degree} \times \frac{\pi}{180}$$

Revolution ConversionFrom **revolution to radians**:

$$\text{Radians} = \text{rev} \times 2\pi$$

From **radians to revolution**:

$$\text{rev} = \text{radians} \div 2\pi$$

Choose the correct answer:Which of the following is a unit used to measure an object's **rotation**?

- (a) Meter (b) Newton (c) Radian (d) Kilogram

One complete **revolution** (360°) is equal to:

- (a) $\pi/4$ rad (b) $\pi/2$ rad (c) π rad (d) 2π rad

A **degree** is equal to:

- (a) $1/360$ of a revolution (b) $1/500$ of a revolution (c) $1/2\pi$ of a revolution (d) $1/4$ of a revolution

Convert 90° to **radians**.

- (a) π rad (b) $\pi/2$ rad (c) 2π rad (d) $\pi/4$ rad

Convert π **radians** to **degrees**.

- (a) 90° (b) 180° (c) 270° (d) 360°

Which **rotation** is considered **positive**?

- (a) Clockwise (b) Downward (c) Counterclockwise (d) Horizontal

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An object rotates **clockwise** through an angle of 90° . Its **angular displacement** is:

- (a) $+\pi/2$ rad (b) $-\pi/2$ rad (c) $+\pi$ rad (d) $-\pi$ rad

How many **revolutions** are equal to **4π radians**?

- (a) 1 rev (b) 2 rev (c) 3 rev (d) 4 rev

Convert **270°** to **radians**.

- (a) $\pi/2$ rad (b) π rad (c) $3\pi/2$ rad (d) 2π rad

A wheel rotates **counterclockwise** through **one-quarter revolution**. The **angular displacement** is:

- (a) $-\pi/2$ rad (b) $+\pi/2$ rad (c) $-\pi$ rad (d) $+\pi$ rad

Earth's Rotation

We know that:

$$24 \text{ h} = 1 \text{ revolution} = 360^\circ = 2\pi \text{ rad}$$

This means that the Earth completes one full rotation in **24 hours**.

General Formula

To calculate **angular displacement**:

$$\theta = \frac{\text{time}}{24} \times 2\pi$$

Where:

- θ = angular displacement in radians
- time = time in hours

Choose the correct answer:

Earth rotates through how many **radians** in **12 h**?

- (a) $\pi/2$ rad (b) π rad (c) 2π rad (d) 3π rad

Earth rotates through how many **radians** in **6 h**?

- (a) $\pi/2$ rad (b) π rad (c) 2π rad (d) $\pi/4$ rad

Earth rotates through how many **radians** in **1 h**?

- (a) $\pi/24$ rad (b) $\pi/12$ rad (c) $\pi/6$ rad (d) $\pi/2$ rad

Earth rotates through how many **radians** in **1.5 h**?

- (a) $\pi/12$ rad (b) $\pi/6$ rad (c) $\pi/8$ rad (d) $\pi/4$ rad

The Earth rotates a total of how many **radians** in **24 h**?

- (a) π rad (b) $\pi/2$ rad (c) 2π rad (d) 4π rad

For the **minute hand** of a clock, what is the **angular displacement** in one hour?

- (a) π rad (b) π rad (c) 2π rad (d) 2π rad

Which angle represents **half a revolution**?

- (a) $\pi/2$ rad (b) π rad (c) 2π rad (d) 3π rad

Learning Outcome 2

Relate the **arc length (x)** to the **angular displacement (θ)** and the **distance (r)** from the axis of rotation.

Explanation: Arc Length

When an object rotates, a point on the object moves along a **circular path**.

The distance moved along the circular path is called **arc length**.

Relationship between arc length and angular displacement:

$$x = r\theta$$

Where:

- x = arc length
- r = radius
- θ = angular displacement in radians

Important Note

⚠ The angle (θ) must be in **radians**, not degrees.

If the angle is given in degrees, convert it to radians first before applying the equation.

Key Notes

- If $\theta = 1$ rad

Then:

$$x = r$$

- If $\theta = 2$ rad

Then:

$$x = 2r$$

- If $\theta = \pi$ rad

Then:

$$x = \pi r$$

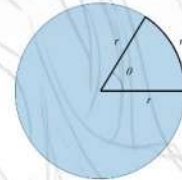
Choose the correct answer:

What is the **arc length** for an angle of **2 rad**?

- (a) Four times the radius (b) Twice the radius (c) Half the radius (d) Equal to the radius

The diagram shows a sector of a circle with **radius r**.The **arc length** of the sector is **r**.What is the measure of angle θ ?

- (a) 30° (b) 57° (c) 60° (d) 180°

A motorbike completes **half a revolution** around a circular racing track.If the **diameter** of the track is **300 m**, what distance does the bike travel?(Give your answer to **two significant figures**)

- (a) 48 m (b) 480 m (c) 47 m (d) 470 m

A wheel is rotated so that a point on the edge moves through **1.50 m**.The **radius** of the wheel is **2.50 m**.What angle, in **radians**, is the wheel rotated?

- (a) 0.60 rad (b) 1.50 rad (c) 2.50 rad (d) 4.00 rad

A steering wheel is rotated through **128°** .Its **radius** is **22 cm**.

How far would a point on the steering wheel's edge move?

- (a) 24 cm (b) 49 cm (c) 56 cm (d) 128 cm



The **radius** of a circle is **10 m** and the **angular displacement** is **3 rad**.
Find the **arc length**.

- (a) 10 m (b) 13 m (c) 30 m (d) 300 m

An object moves through an **arc length** of **18 m** around a circle of **radius 6 m**.
Find the **angular displacement**.

- (a) 2 rad (b) 3 rad (c) 4 rad (d) 6 rad

A point moves through an **arc length** equal to πr .
The angular displacement is:

- (a) $\pi/2$ rad (b) π rad (c) 2π rad (d) 3π rad

A wheel of **radius 0.5 m** rotates through **4 rad**.
What **distance** does a point on the rim travel?

- (a) 1 m (b) 2 m (c) 4 m (d) 8 m

A circular path has **radius 15 cm** and **arc length 45 cm**.
Find the angle θ .

- (a) 1 rad (b) 2 rad (c) 3 rad (d) 4 rad

If the **angular displacement** doubles while the **radius remains constant**, the **arc length** will:

- (a) Remain constant (b) Be halved (c) Double (d) Become zero

A point travels an **arc length** of 20π cm on a circle of **radius 10 cm**.
Find θ .

- (a) π rad (b) 2π rad (c) 3π rad (d) 4π rad

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Learning Outcome 3

Objective

- Apply the relationship between **angular velocity (ω)**, **angular displacement ($\Delta\theta$)**, and **time interval (Δt)**
- Solve problems related to **rotational motion**

Explanation: Angular Velocity

Angular velocity describes how fast an object rotates.

$$\omega = \frac{\Delta\theta}{\Delta t}$$

Where:

- ω = angular velocity
- $\Delta\theta$ = angular displacement
- Δt = time interval

Unit

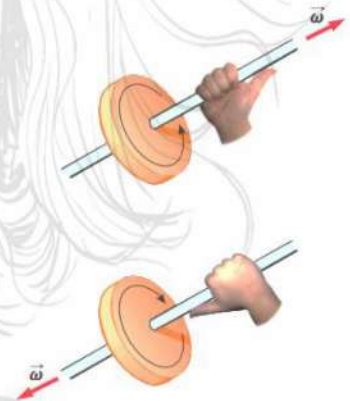
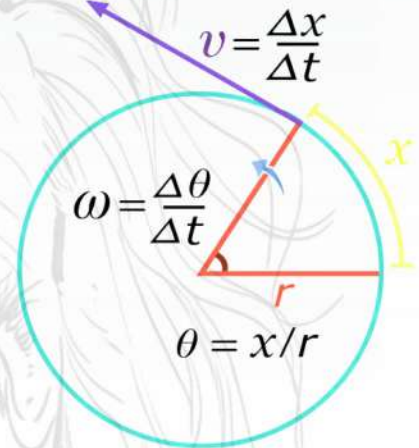
rad/s

Important Notes

- Counterclockwise rotation $\rightarrow$ positive ω
- Clockwise rotation $\rightarrow$ negative ω

$$1 \text{ rev} = 2\pi \text{ rad}$$

$$\omega = \text{rpm} \times \frac{2\pi}{60}$$



Solved Examples

Example 1

$$\Delta\theta = 2.6 \text{ rad}, \Delta t = 20.0 \text{ s}$$

$$\omega = \frac{2.6}{20.0} = 0.13 \text{ rad/s}$$

Example 2

$$\Delta\theta = 1.90 \text{ rad}, \Delta t = 50.0 \text{ s}$$

$$\omega = \frac{1.90}{50.0} = 0.038 \text{ rad/s}$$

An object rotates through an **angular displacement** of **2.9 rad** in **25 s**.
What is its **average angular velocity**?

- (a) 73 rad/s (b) 0.12 rad/s (c) 3.0 rad/s (d) 8.6 rad/s

A record rotates **clockwise** at **33.3 rev/min**.
What is its **angular speed** in **rad/s**?

- (a) 3.49 rad/s (b) 1.75 rad/s (c) 0.29 rad/s (d) 209 rad/s

A motor rotates at **5000 rpm**.
What is its **angular speed** in **rad/s**?

- (a) 524 rad/s (b) 420 rad/s (c) 240 rad/s (d) 120 rad/s

An object completes **one revolution (2π rad)** in **2 s**.
What is its **angular velocity**?

- (a) $4/3 \pi$ rad/s (b) $1/2 \pi$ rad/s (c) 2π rad/s (d) π rad/s

An object rotates through **8 rad** in **4 s**.
What is its **angular velocity**?

- (a) 0.5 rad/s (b) 2 rad/s (c) 4 rad/s (d) 32 rad/s

A wheel rotates **counterclockwise** through **12 rad** in **3 s**.
What is its **angular velocity**?

- (a) -4 rad/s (b) $+4$ rad/s (c) $+36$ rad/s (d) -36 rad/s

A wheel rotates **clockwise** through **6 rad** in **2 s**.
What is its **angular velocity**?

- (a) $+3$ rad/s (b) -3 rad/s (c) $+12$ rad/s (d) -12 rad/s

An object undergoes an **angular displacement** of **10 rad** in **5 s**.
Which **equation** is used to calculate its **angular velocity**?

- (a) $\omega = \Delta t \times \Delta \theta$ (b) $\omega = \Delta \theta / \Delta t$ (c) $\omega = \Delta t / \Delta \theta$ (d) $\omega = \theta / r$

The **hour hand** rotates for **4 h**.
What is its **angular displacement**?

- (a) $\pi/3$ rad (b) $2\pi/3$ rad (c) π rad (d) $4\pi/3$ rad

The **minute hand** completes **half a revolution**. How much **time** has passed?

- (a) 15 min (b) 30 min (c) 45 min (d) 60 min

An object rotates through **10 rad** in **5 s**. What is its **angular velocity**?

- (a) 0.5 rad/s (b) 2 rad/s (c) 5 rad/s (d) 50 rad/s

A rotating object has a speed of **60 rev/min**.
What is its **angular speed** in **rad/s**?

- (a) 2π rad/s (b) π rad/s (c) 6π rad/s (d) 12π rad/s

The **minute hand** completes one full revolution in **60 min**.
What is its **angular displacement** in **1 hour**?

- (a) π rad (b) 2π rad (c) $\pi/2$ rad (d) 4π rad

The **second hand** completes **one revolution** in **1 minute**.
What is its **angular displacement**?

- (a) $\pi/2$ rad (b) π rad (c) 2π rad (d) 4π rad

The **hour hand** completes **one revolution** in **12 hours**.
What is its **angular displacement**?

- (a) $\pi/2$ rad (b) π rad (c) 2π rad (d) 4π rad

Angular Displacement

A movie lasts **2 h**.

Determine the **angular displacement** of each hand of the clock during the movie.

What is the **angular displacement** of the **hour hand** during **2 h**?

- (a) $\pi/6$ rad (b) $\pi/3$ rad (c) $\pi/2$ rad (d) π rad

What is the **angular displacement** of the **minute hand** during **2 h**?

- (a) 2π rad (b) 3π rad (c) 4π rad (d) 6π rad

What is the **angular displacement** of the **second hand** during **2 h**?

- (a) 120π rad (b) 180π rad (c) 240π rad (d) 360π rad

Learning Outcome 4

Relate the **linear velocity** (v) to the **angular velocity** (ω) and the **distance** (r) from the axis of rotation.

Solve problems related to **rotational variables**.

Explanation: Linear Speed (Tangential Speed)

When an object rotates, any point located at a distance r from the axis of rotation moves in a **circular path**.

The speed of that point along the curved path is called **linear speed** or **tangential speed**.

Formula

$$v = r\omega$$

Where:

- v = linear speed (m/s)
- r = radius or distance from the center (m)
- ω = angular velocity (rad/s)

Important Notes

- All points on a **rigid rotating object** have the same **angular velocity**.
- Points farther from the center move with greater **linear speed**.
- Linear speed is **directly proportional** to radius.

If radius increases:

$v \uparrow$

If radius decreases:

$v \downarrow$

A wheel rotates with an angular velocity of **4 rad/s**.

A point is located **0.50 m** from the center.

Find the linear speed.

Solution:

$$v = r\omega$$

$$v = (0.50)(4) = 2.0 \text{ m/s}$$

Earth rotates with an angular velocity: $\omega = 7.27 \times 10^{-5} \text{ rad/s}$

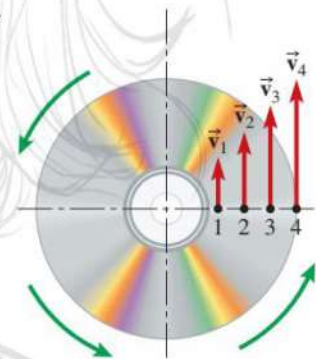
Earth's radius: $r \approx 6.38 \times 10^6 \text{ m}$

Find the linear speed at the equator.

Solution:

$$v = r\omega$$

$$v = (6.38 \times 10^6)(7.27 \times 10^{-5}) = 464 \text{ m/s}$$



Choose the correct answer:

The figure shows **two touching gears**.
Which quantity is the same for both gears?



- (a) Linear speed (b) Angular speed (c) Angular displacement (d) Angular acceleration

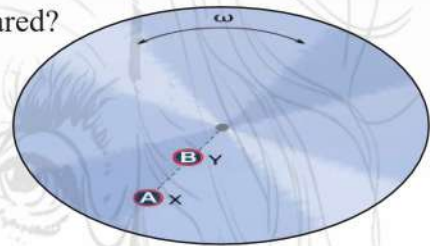
In a clock, all parts of the **minute hand** are equal in:



- (a) Linear speed (b) Angular speed (c) Linear displacement (d) Tangential speed

The figure shows a rotating disk with two points located at different distances from the center.

How can the **angular velocities** of the two points be compared?



- (a) Point B has greater angular velocity
(b) Point A has greater angular velocity
(c) Both angular velocities are zero
(d) Both angular velocities are equal and nonzero

A point on a rotating wheel is **0.20 m** from the center.
If the wheel rotates at **10 rad/s**, what is the **linear speed**?

- (a) 0.5 m/s (b) 2.0 m/s (c) 5.0 m/s (d) 20 m/s

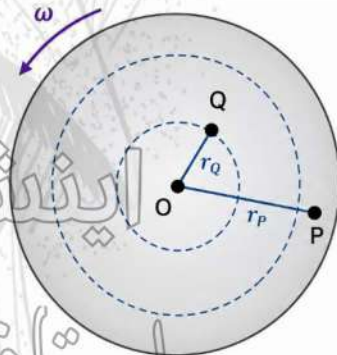
A rotating disk has **angular velocity = 8 rad/s**.
A point located **0.50 m** from the center has **linear speed**:

- (a) 2 m/s (b) 4 m/s (c) 8 m/s (d) 16 m/s

Which **equation** relates **linear speed** and **angular velocity**?

- (a) $v = \omega/r$ (b) $v = r\omega$ (c) $v = r/\omega$ (d) $v = r + \omega$

Two points are located on the same rotating disk.
Point **P** is farther from the center than point **Q**.
Which statement is correct?



- (a) Both points have the same linear speed
(b) Point Q has greater linear speed
(c) Point P has greater linear speed
(d) Both points have zero speed

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A wheel rotates with **angular velocity** = 12 rad/s .

A point on the rim moves at 3.6 m/s . What is the **radius** of the wheel?

- (a) 0.10 m (b) 0.20 m (c) 0.30 m (d) 0.40 m

A wheel rotates at 20 rad/s .

Find the **linear speed** of a point located 0.40 m from the center.

- (a) 4 m/s (b) 8 m/s (c) 12 m/s (d) 16 m/s

A point moves with **linear speed** = 15 m/s and is 0.50 m from the center.

Find the **angular velocity**.

- (a) 10 rad/s (b) 20 rad/s (c) 30 rad/s (d) 40 rad/s

A rotating fan has **radius** = 0.25 m and **angular velocity** = 40 rad/s .

Find the **linear speed** at the tip.

- (a) 5 m/s (b) 10 m/s (c) 15 m/s (d) 20 m/s

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Learning Outcome 5

Apply the relationship between **average angular acceleration (α)**, **change in angular velocity ($\Delta\omega$)**, and **time interval (Δt)**.

Solve problems related to **rotational variables**.

Explanation: Angular Acceleration

Angular acceleration describes how quickly **angular velocity** changes with time.

$$\alpha = \frac{\Delta\omega}{\Delta t}$$

$$\Delta\omega = \omega_f - \omega_i$$

Where:

- α = angular acceleration (rad/s^2)
- ω_i = initial angular velocity
- ω_f = final angular velocity
- $\Delta\omega$ = change in angular velocity
- Δt = time interval

Sign Convention

- If **angular velocity increases** in the **counterclockwise direction** $\rightarrow$ **positive angular acceleration**
- If **angular velocity decreases** $\rightarrow$ **negative angular acceleration**
- **Clockwise rotation** is usually considered **negative**

Choose the correct answer:

A flywheel increases its **angular speed** from **5 rad/s** to **15 rad/s** in **5 s**.
What is the **angular acceleration**?

- (a) 6 rad/s^2 (b) 4 rad/s^2 (c) 3 rad/s^2 (d) 2 rad/s^2

A fan slows from **10 rad/s** to **6.30 rad/s** in **5.00 s**.
What is the **magnitude of angular acceleration**?

- (a) 1.35 rad/s^2 (b) 0.921 rad/s^2 (c) 0.740 rad/s^2 (d) 0.360 rad/s^2

A blender blade spins from **rest** to **9000 rev/min** in **4.5 s**. What is the **angular acceleration**?

- (a) 756 rad/s^2 (b) 2000 rad/s^2 (c) 12.6 rad/s^2 (d) 209 rad/s^2

A CD starts rotating from **rest** and reaches **$6\pi \text{ rad/s}$** in **3.0 s**.

What is the **angular acceleration**?

- (a) $6\pi \text{ rad/s}^2$ (b) $4\pi \text{ rad/s}^2$ (c) $2\pi \text{ rad/s}^2$ (d) $\pi \text{ rad/s}^2$

A centrifuge rotor is accelerated for **20 s** from **rest** to **10000 rpm**.
What is its **average angular acceleration**?

- (a) 558 rad/s^2 (b) 17.3 rad/s^2 (c) 1050 rad/s^2 (d) 52.5 rad/s^2

A wheel increases its **angular velocity** from **8 rad/s** to **20 rad/s** in **4 s**.
What is the **angular acceleration**?

- (a) 2 rad/s^2 (b) 3 rad/s^2 (c) 4 rad/s^2 (d) 5 rad/s^2

A rotating fan changes its **angular velocity** from **30 rad/s** to **10 rad/s** in **5 s**.
What is the **angular acceleration**?

- (a) -2 rad/s^2 (b) -4 rad/s^2 (c) 2 rad/s^2 (d) 4 rad/s^2

A wheel rotates **clockwise** and its angular speed changes from **-12 rad/s** to **-4 rad/s** in **4 s**.
What is the **angular acceleration**?

- (a) $+2 \text{ rad/s}^2$ (b) -2 rad/s^2 (c) $+4 \text{ rad/s}^2$ (d) -4 rad/s^2

A rotating disk changes from **0 rad/s** to **24 rad/s** in **8 s**.
Find the **average angular acceleration**.

- (a) 2 rad/s^2 (b) 3 rad/s^2 (c) 4 rad/s^2 (d) 6 rad/s^2

A wheel rotates from **25 rad/s** to **5 rad/s** in **10 s**.
What is the **angular acceleration**?

- (a) -1 rad/s^2 (b) -2 rad/s^2 (c) 2 rad/s^2 (d) 5 rad/s^2

A rotating object starts from **rest** and reaches **40 rad/s** after **5 s**.
What is its **angular acceleration**?

- (a) 6 rad/s^2 (b) 8 rad/s^2 (c) 10 rad/s^2 (d) 12 rad/s^2

An object changes its **angular velocity** by **30 rad/s** in **10 s**.
Find **α** .

- (a) 1 rad/s^2 (b) 2 rad/s^2 (c) 3 rad/s^2 (d) 4 rad/s^2

A wheel initially rotates at **-20 rad/s** and stops after **4 s**.
What is the **angular acceleration**?

- (a) $+5 \text{ rad/s}^2$ (b) -5 rad/s^2 (c) $+4 \text{ rad/s}^2$ (d) -4 rad/s^2

Learning Outcome 6

Define the term **torque**.

Identify that **torque involves a force and a lever arm**, which is the perpendicular distance from the axis of rotation to the point where the force is applied.

Explanation: Torque

Torque is the **turning effect of a force**.

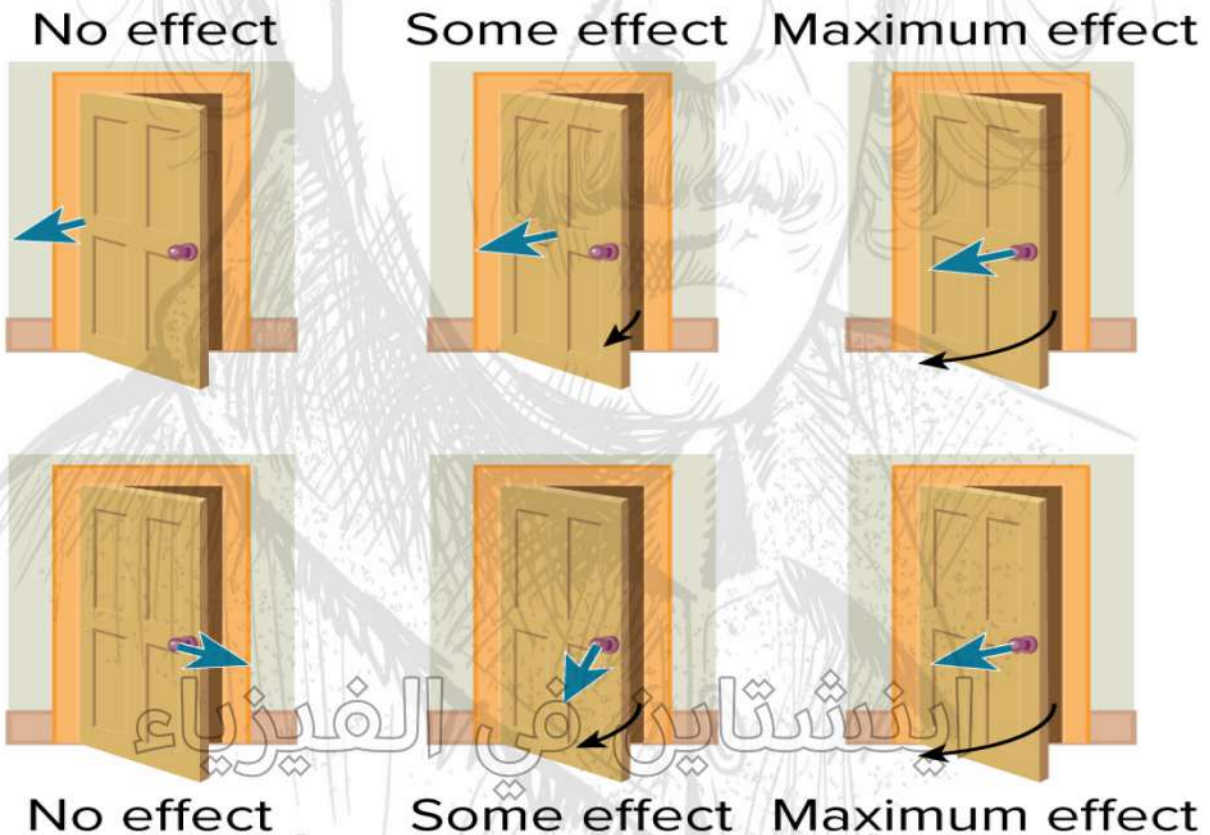
A force can make an object rotate only if:

- the force is applied at a **distance from the axis of rotation**
- the force is applied in a **suitable direction**

Effect of Force: Opening a Door

The effect of force on rotation depends on:

- the **point of application**
- the **direction of the force**



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Why Some Forces Rotate the Door and Others Do Not**Force $F_1 \rightarrow$ No Rotation**

- Applied very close to the **axis of rotation (hinges)**
- Lever arm $\approx$ zero
- Torque becomes nearly zero

Result:

Does not rotate the door

Force $F_2 \rightarrow$ Causes Rotation Easily

- Applied far from the **hinges**
- Lever arm is maximum
- Force is **perpendicular** to the door

Result:

Produces maximum rotation

Force $F_3 \rightarrow$ No Rotation

- Applied far from the hinges
- Force acts **parallel** to the door

Since:

$$\tau = Fr \sin \theta$$

At:

$$\theta = 0^\circ$$

$$\text{Torque} = 0$$

Result:

No rotation occurs

Maximum Rotational Effect Occurs When

✓ Force is applied **far from the hinges**

✓ Force is applied **perpendicular (90°)**

Force near hinges $\rightarrow$ almost no effect

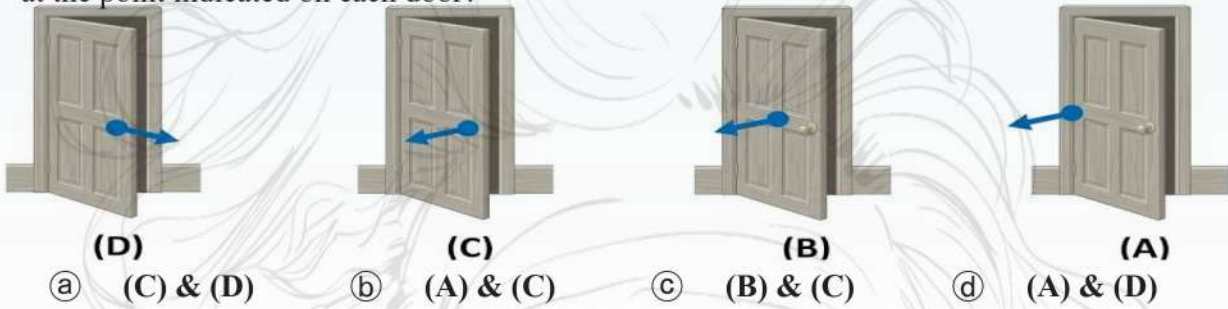
Force at middle $\rightarrow$ some effect

Force at outer edge $\rightarrow$ maximum effect

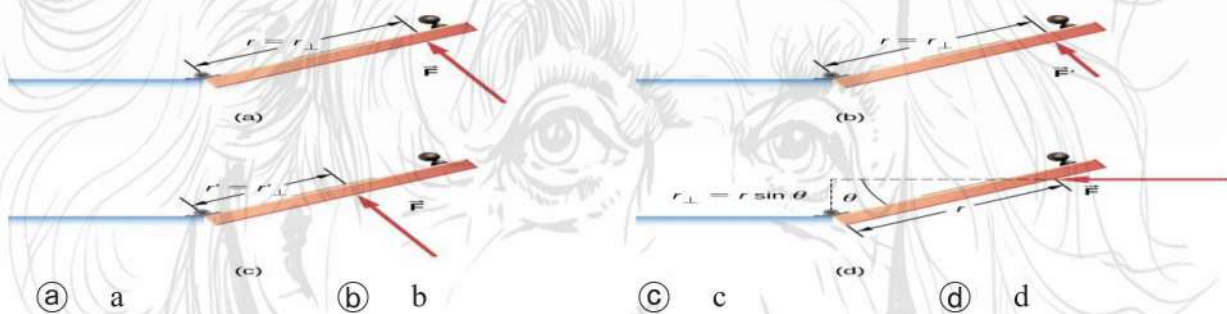
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Choose the correct answer:

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



The door that has **the greatest torque** on is



In the illustration, why is there little to no effect in the **top-left door**?

- a The force is applied **parallel to the lever arm**
- b The force is applied **perpendicular to the lever arm**
- c The force is applied **perpendicular to the axis**
- d The force is applied **at the axis of rotation**

The greatest **torque** on a door occurs when the force is applied:

- a near the hinges and parallel to the door
- b near the hinges and perpendicular to the door
- c far from the hinges and perpendicular to the door
- d far from the hinges and parallel to the door

If the same force is applied to a door, the torque is greatest when force acts:

- a at hinges b at middle c at outer edge d along the door

Which force produces **zero torque**?

- a A force applied perpendicular to the lever arm
- b A force applied far from the axis
- c A force applied through the axis of rotation
- d A force applied at the handle

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Learning Outcome 7

Apply the relation $\tau = Fr \sin \theta$ to calculate **torque**.

Identify **positive** and **negative torque** depending on the direction of rotation.

Clockwise torque → **Negative**

Explanation: Torque Calculation

Torque is the **turning effect of a force**.

Relationship:

$$\tau = Fr \sin \theta$$

Where:

- τ = torque (N·m)
- F = force (N)
- r = distance from axis (m)
- θ = angle between force and radius (or handle)

Sign of Torque

- **Counterclockwise rotation** → **Positive torque (+)**
- **Clockwise rotation** → **Negative torque (-)**

Important Cases

If force is **perpendicular**:

$$\theta = 90^\circ$$

$$\tau = Fr$$

Torque becomes **maximum**

If force is **parallel**:

$$\theta = 0^\circ$$

$$\text{Torque} = 0$$

Choose the correct answer:

A **door** is **0.90 m** wide and a **force of 2.0 N** is applied **perpendicular** to the door.

What is the **magnitude of torque**?

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

A **torque of 45.0 N·m** is needed to tighten a bolt.

A **0.341 m wrench** is used, and the maximum force is **189 N**.

What is the **smallest angle** with respect to the wrench?

- (a) 44.3° (b) 43.4° (c) 34.3° (d) 33.4°

A **force of 70.0 N** is applied to a wrench at an angle of **50.0°**.

If the **torque** equals **15.0 N·m**, what is the **length of the wrench**?

- (a) 33 cm (b) 28 cm (c) 21 cm (d) 18 cm

A **40 N force** is applied **perpendicular** to a **0.50 m wrench**. What is the **torque**?

- (a) 10 N·m (b) 20 N·m (c) 40 N·m (d) 80 N·m

A force is applied **parallel** to a wrench. What is the **torque**?

- (a) Maximum (b) Zero (c) Equal to Fr (d) Equal to F/r

Which **torque** is **negative**?

- (a) Counterclockwise torque (b) Clockwise torque (c) Maximum torque (d) Zero torque

A **force of 25 N** is applied **perpendicular** to a wrench of length **0.80 m**.

Find the **torque**.

- (a) $10 \text{ N}\cdot\text{m}$ (b) $20 \text{ N}\cdot\text{m}$ (c) $30 \text{ N}\cdot\text{m}$ (d) $40 \text{ N}\cdot\text{m}$

A **force of 60 N** acts at an angle of 30° on a **0.50 m lever arm**.

Find the **torque**.

- (a) $10 \text{ N}\cdot\text{m}$ (b) $15 \text{ N}\cdot\text{m}$ (c) $20 \text{ N}\cdot\text{m}$ (d) $30 \text{ N}\cdot\text{m}$

A **50 N force** acts at 90° to a **0.40 m handle**.

What is the **torque**?

- (a) $10 \text{ N}\cdot\text{m}$ (b) $20 \text{ N}\cdot\text{m}$ (c) $30 \text{ N}\cdot\text{m}$ (d) $40 \text{ N}\cdot\text{m}$

A **100 N force** is applied at 0° to a **0.60 m wrench**.

What torque is produced?

- (a) $0 \text{ N}\cdot\text{m}$ (b) $6 \text{ N}\cdot\text{m}$ (c) $60 \text{ N}\cdot\text{m}$ (d) $100 \text{ N}\cdot\text{m}$

A force creates **counterclockwise rotation**. The torque is:

- (a) Positive (b) Negative (c) Zero (d) Undefined

If the **distance from the axis doubles** while force remains constant, the **torque** becomes:

- (a) Half (b) D (c) Zero (d) Unchanged

A **20 N force** is applied at 60° to a **0.50 m wrench**.

Find the **torque**.

- (a) $5.0 \text{ N}\cdot\text{m}$ (b) $8.7 \text{ N}\cdot\text{m}$ (c) $10.0 \text{ N}\cdot\text{m}$ (d) $17.3 \text{ N}\cdot\text{m}$

If a **torque of $55.0 \text{ N}\cdot\text{m}$** is required to turn a bolt and the **largest force** you can exert is **135 N**, what **lever arm length** must be used?

- (a) 0.41 m (b) 0.31 m (c) 0.22 m (d) 0.15 m

You have a **0.234 m-long wrench**. A job requires a **torque of $32.4 \text{ N}\cdot\text{m}$** , and you can exert a **force of 232 N**. What is the **smallest angle** (with respect to the handle of the wrench) that allows you to accomplish the job?

- (a) 36.7° (b) 41.2° (c) 51.4° (d) 63.3°

A friend can exert **275 N** using the same **0.234 m wrench**.

What is the **smallest angle** she can use to accomplish the job?

- (a) 18.4° (b) 30.2° (c) 41.2° (d) 51.4°

Learning Outcome 8

Solve problems that involve **torque**.

Calculate the **net torque** when more than one torque acts on a body about a rotation axis.

Explanation: Net Torque

When more than one torque acts on an object:

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

Sign Rule

- **Counterclockwise torque** → **Positive (+)**
- **Clockwise torque** → **Negative ()**

If:

$$\tau_{net} = 0$$

The object is in **rotational equilibrium** and does not rotate.

Important Formula

Torque:

$$\tau = Fr$$

or

$$\tau = Fr \sin \theta$$

For balance:

$$\sum \tau = 0$$

Therefore:

$$F_1 r_1 = F_2 r_2$$

Choose the correct answer:

Fatimah has a **mass of 56 kg**, and Aisha has a **mass of 43 kg**.

Aisha sits **1.5 m** from the pivot.

At what distance should Fatimah sit to **balance the seesaw**?

- (a) 1.5 m (b) 0.85 m (c) 1.0 m (d) 1.15 m

A system consists of **two pulleys** fixed together and rotating about a common axis.

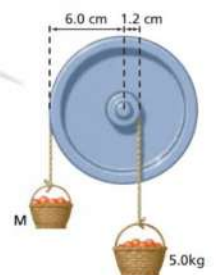
The system is in **equilibrium**.

The right bucket has a **mass of 5.0 kg** and hangs at a **radius of 1.2 cm**.

The left bucket has an unknown **mass M** and hangs at a **radius of 6.0 cm**.

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

- (a) 25 kg (b) 5.0 kg (c) 2.5 kg (d) 1.0 kg



Two **fruit baskets** are suspended from two ropes as shown.

The left basket has **mass m** and hangs **0.28 m** from the support.

The right basket has **mass 0.8 kg** and hangs **0.16 m** from the support.

What value of **m** makes the baskets balance **without rotation**?

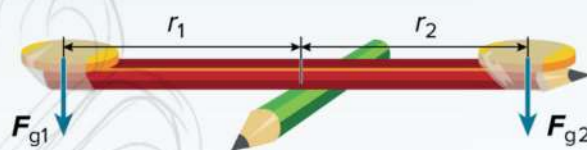
- (a) 1.40 kg (b) 0.60 kg (c) 0.46 kg (d) 1.26 kg



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



The figure shows **Mohammad** and his sister **Laila** sitting on a **seesaw** and trying to balance it. Which action 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

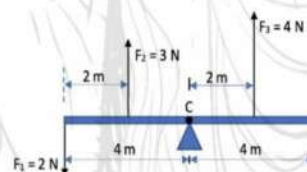


The figure shows a **uniform seesaw** rotating about a **pivot at point C**.

Three forces act on the seesaw as shown.

What is the **net torque** produced by the forces about **point C**, and in which **direction** does the seesaw rotate?

- Ⓐ 6 N·m, clockwise
- Ⓑ 8 N·m, counterclockwise
- Ⓒ 10 N·m, clockwise
- Ⓓ 12 N·m, counterclockwise

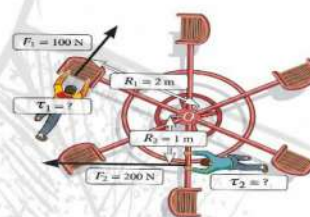


The figure shows two workers applying forces to a rotating **wheel-like device**.

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**?

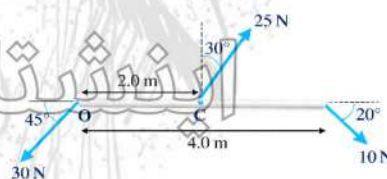
- Ⓐ 0 N·m, no rotation
- Ⓑ 200 N·m, clockwise
- Ⓒ 200 N·m, counterclockwise
- Ⓓ 400 N·m, counterclockwise



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 N·m clockwise
- Ⓑ 22 N·m counterclockwise
- Ⓒ 30 N·m clockwise
- Ⓓ 37 N·m counterclockwise



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Learning Outcome 9

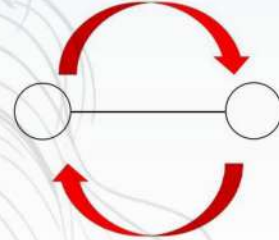
Define **moment of inertia** as the **resistance to rotation**.

Explanation: Moment of Inertia

The **moment of inertia** is the **resistance of an object to rotational motion**.

It describes how difficult it is to:

- **start rotation**
- **stop rotation**
- **change rotational motion**

**The Moment of Inertia Depends On**

- the **mass of the object**
- how the **mass is distributed relative to the axis of rotation**

Objects with **more mass farther from the axis** have a **greater moment of inertia** and are harder to rotate.

Objects with **mass closer to the axis** have a **smaller moment of inertia** and rotate more easily.

Important Notes

- Greater **mass** → greater **moment of inertia**
- Greater **distance from the axis** → greater **moment of inertia**
- Moment of inertia depends on the **axis of rotation**

Choose the correct answer:

The **resistance to rotation** is called:

- (a) Friction (b) Moment of resistance (c) Torque (d) Moment of inertia

The quantity that represents the **resistance of an object to rotational motion** is:

- (a) Torque (b) Angular acceleration (c) Moment of inertia (d) Linear velocity

If the **distance from the axis increases**, the **moment of inertia** will:

- (a) decrease (b) remain constant (c) increase (d) become zero

The **moment of inertia** describes how difficult it is to:

- (a) increase linear speed (b) start or stop rotational motion
(c) increase force only (d) change temperature

Two objects have the **same mass**.

Which object has the **greater moment of inertia**?

- (a) The object with mass closer to the axis
(b) The object with mass farther from the axis
(c) Both are equal
(d) Cannot be determined

Which statement concerning the **moment of inertia** is correct?

- Ⓐ It is independent of the axis of rotation
- Ⓑ It depends on the axis of rotation
- Ⓒ It depends only on mass
- Ⓓ It depends only on force

Which factor affects the **moment of inertia**?

- Ⓐ Mass only
- Ⓑ Distribution of mass only
- Ⓒ Mass and distribution of mass
- Ⓓ Angular velocity only

The SI unit of **moment of inertia** is:

- Ⓐ $\text{N}\cdot\text{m}$
- Ⓑ $\text{kg}\cdot\text{m}^2$
- Ⓒ kg/s^2
- Ⓓ rad/s^2

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Learning Outcome 10

Calculate the **moment of inertia (rotational inertia)** of a **single point mass** rotating about an axis.

Moment of Inertia of a Point Mass**Definition**

The **moment of inertia** measures the **resistance of an object to rotational motion**.

For a **single point mass**:

$$I = mr^2$$

Where:

- **I** = moment of inertia ($\text{kg} \cdot \text{m}^2$)
- **m** = mass (kg)
- **r** = distance from the axis of rotation (m)

Important Notes

- Larger **mass** → larger **moment of inertia**
- Larger **distance from the axis** → much larger **moment of inertia**
- Moment of inertia depends on **distance squared**
- Doubling the distance increases **I** by **4 times**

A rotating object has **moment of inertia** = $8 \text{ kg} \cdot \text{m}^2$ and **mass** = 2 kg .

Find the **distance from the axis**.

- (a) 1 m (b) 2 m (c) 3 m (d) 4 m

A rotating object has **moment of inertia** = $18 \text{ kg} \cdot \text{m}^2$ and rotates at a **distance of 3.0 m**.

Find the **mass**.

- (a) 1 kg (b) 2 kg (c) 3 kg (d) 4 kg

A rotating object has **moment of inertia** = $12 \text{ kg} \cdot \text{m}^2$ and **mass** = 3.0 kg .

Find the **radius**.

- (a) 1 m (b) 2 m (c) 3 m (d) 4 m

A point mass of 8 kg rotates 0.50 m from the axis.

What is the **moment of inertia**?

- (a) $1 \text{ kg} \cdot \text{m}^2$ (b) $2 \text{ kg} \cdot \text{m}^2$ (c) $3 \text{ kg} \cdot \text{m}^2$ (d) $4 \text{ kg} \cdot \text{m}^2$

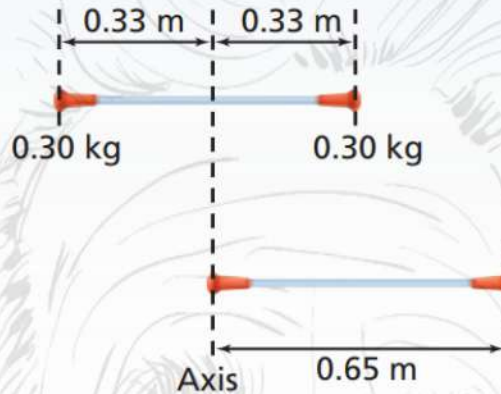
A rotating object has **moment of inertia** = $50 \text{ kg} \cdot \text{m}^2$ and **radius** = 5 m .

Find the **mass**.

- (a) 1 kg (b) 2 kg (c) 3 kg (d) 4 kg

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A simplified model of a **twirling baton** consists of a thin rod with **two round objects** at each end. The **length of the baton** is **0.66 m**, and the **mass of each object** is **0.30 kg**. Assume the **mass of the rod** is **negligible**.



The baton rotates about an axis passing through the **midpoint between the two masses** and **perpendicular to the rod**.

What is the **moment of inertia** of the baton?

- (a) $0.033 \text{ kg}\cdot\text{m}^2$ (b) $0.066 \text{ kg}\cdot\text{m}^2$ (c) $0.130 \text{ kg}\cdot\text{m}^2$ (d) $0.260 \text{ kg}\cdot\text{m}^2$

The axis of rotation is moved to **one end of the rod**.

What is the **moment of inertia** of the baton?

- (a) $0.033 \text{ kg}\cdot\text{m}^2$ (b) $0.066 \text{ kg}\cdot\text{m}^2$ (c) $0.130 \text{ kg}\cdot\text{m}^2$ (d) $0.260 \text{ kg}\cdot\text{m}^2$

Two children of **equal masses** sit **0.30 m** from the center of a **seesaw**.

Assuming that their masses are much greater than the mass of the seesaw, by how much is the **moment of inertia** increased when they move to **0.60 m** from the center?

- (a) doubled (b) tripled (c) four times (d) unchanged

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Learning Outcome 11

Demonstrate how the **moment of inertia** of an **extended object** depends on the **location** and **direction** of the rotational axis.

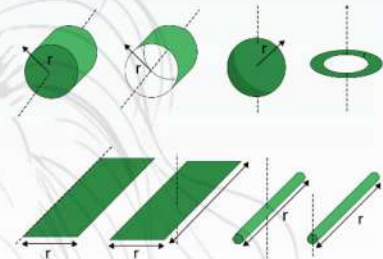
Determine the **moment of inertia** of extended objects such as **solid uniform cylinder**, **uniform sphere**, and **long uniform rod**.

Moment of Inertia of Extended Objects**Main Idea**

The **moment of inertia** is not the same for all objects.

It depends on:

- **mass**
- **shape**
- **distribution of mass**
- **location of the axis of rotation**
- **direction of the axis of rotation**

**Important Rule**

If more **mass** is farther from the axis, the **moment of inertia** increases.

If more **mass** is closer to the axis, the **moment of inertia** decreases.

Table: Moments of Inertia of Common Objects

Object	Location of Axis	Diagram	Moment of Inertia
Thin hoop of radius r	through central diameter		mr^2
Solid, uniform cylinder of radius r	through center		$\left(\frac{1}{2}\right)mr^2$
Uniform sphere of radius r	through center		$\left(\frac{2}{5}\right)mr^2$
Long, uniform rod of length l	through center		$\left(\frac{1}{12}\right)ml^2$
Long, uniform rod of length l	through end		$\left(\frac{1}{3}\right)ml^2$
Thin, rectangular plate of length l and width w	through center		$\left(\frac{1}{12}\right)m(l^2 + w^2)$

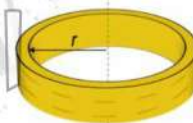
1. Thin Hoop (radius r)

- **Axis:** through the central diameter
- **Moment of Inertia:**

$$I = mr^2$$

$$I = mxr^2$$

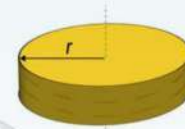
All the mass is located at the same distance from the axis, so the moment of inertia is relatively large.



2. Solid Uniform Cylinder (radius r)

- **Axis:** through the center
- **Moment of Inertia:**

$$I = \frac{1}{2}mr^2$$



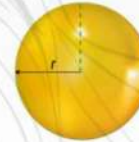
$$I = \frac{1}{2}m \times r^2$$

The mass is distributed from the center outward, so the resistance to rotation is less than that of a hoop.

3. Uniform Solid Sphere (radius r)

- **Axis:** through the center
- **Moment of Inertia:**

$$I = \frac{2}{5}mr^2$$



$$I = \frac{2}{5}m \times r^2$$

Most of the mass is closer to the axis, making it easier to rotate than a cylinder or hoop of the same mass.

4. Long Uniform Rod (length l)

(a) Axis through the center

$$I = \frac{1}{12}ml^2$$



(b) Axis through one end

$$I = \frac{1}{3}ml^2$$

$$I = \frac{1}{12}m \times l^2$$

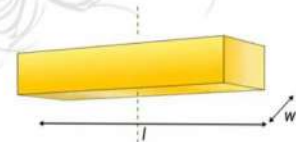
$$I = \frac{1}{3}m \times l^2$$

Placing the axis at the end increases the average distance of the mass from the axis, increasing the moment of inertia.

5. Thin Rectangular Plate (length l, width w)

- **Axis:** through the center
- **Moment of Inertia:**

$$I = \frac{1}{12}m(l^2 + w^2)$$



$$I = \frac{1}{12}m \times (l^2 + w^2)$$

The contribution of both dimensions affects the resistance to rotation.

Important Notes

- A **thin hoop** has a larger **moment of inertia** than a **solid cylinder** of the same mass and radius.
- A **solid sphere** has a smaller **moment of inertia** than a cylinder of the same mass and radius.
- A **rod rotated about its end** has a greater moment of inertia than the same rod rotated about its center.
- Changing the **axis of rotation** changes the moment of inertia.

The **moment of inertia** of an extended object depends on:

- Ⓐ mass only Ⓑ radius only Ⓒ shape and axis of rotation Ⓓ angular velocity only

Choose the correct answer:

A **thin hoop** and a **solid cylinder** have equal **mass and radius**.

Which has the **greater resistance to rotation**?

- (a) Hoop (b) Cylinder (c) Equal (d) Depends on angular velocity

What is the **moment of inertia** of a **solid uniform cylinder** of mass **m** and radius **r**?

- (a) $I = mr^2$ (b) $I = \frac{1}{2}mr^2$ (c) $I = \frac{2}{5}mr^2$ (d) $I = \frac{1}{12}ml^2$

What is the **moment of inertia** of a **uniform solid sphere**?

- (a) $I = mr^2$ (b) $I = \frac{1}{2}mr^2$ (c) $I = \frac{2}{5}mr^2$ (d) $I = \frac{1}{3}ml^2$

A **long uniform rod** rotates about its **center**.

Its moment of inertia is:

- (a) $I = \frac{1}{12}ml^2$ (b) $I = \frac{1}{3}ml^2$ (c) $I = mr^2$ (d) $I = \frac{1}{2}mr^2$

A **long uniform rod** rotates about **one end**.

Its moment of inertia is:

- (a) $I = \frac{1}{12}ml^2$ (b) $I = \frac{1}{3}ml^2$ (c) $I = \frac{2}{5}mr^2$ (d) $I = mr^2$

Which object has the **greatest moment of inertia** for the same **mass and radius**?

- (a) Solid sphere (b) Solid cylinder (c) Thin hoop (d) All are equal

Why does a **hoop** have a larger **moment of inertia** than a **solid cylinder** of the same mass and radius?

- (a) Its mass is closer to the axis (b) Its mass is farther from the axis
(c) It has less mass (d) It has no axis of rotation

Changing the **axis of rotation** of an object:

- (a) does not affect the moment of inertia (b) changes the moment of inertia
(c) changes only the mass (d) changes only angular velocity

A **rod** is easier to rotate when the axis is:

- (a) through one end (b) through the center (c) outside the rod (d) parallel to the rod

Which statement is correct?

- (a) Moment of inertia is independent of mass distribution
(b) Moment of inertia depends on the location of the rotational axis
(c) Moment of inertia depends only on speed
(d) Moment of inertia is measured in $N \cdot m$

For the same **mass and length**, which rod has the **smaller moment of inertia**?

- (a) Rotating through center (b) Rotating through one end
(c) Both equal (d) Cannot be determined