8
Module

Rotational Motion
Lesson 1: Describing Rotational Motion

Main words
Rotational Motion - Angular Displacement linear distance (arc length)
Angular Velocity - Angular Acceleration - Angular Frequency

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| Lesson: | Describing Rotational Motion |
| ONE | |

| Lesson: | Rotational Dynamics |
| TWO | |

| Lesson: | Equilibrium |
| THREE | |

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8.1 - Rotational Equations of Motion

The two most fundamental types are translational motion and rotational motion.

- **Translational Motion** occurs when all points of an object move in the same direction and cover the same distance—such as a car moving straight down a road.

- **Rotational Motion**, on the other hand, occurs when an object spins or turns about a fixed axis, causing different points on the object to move along circular paths of different radii.

I. Rotational Motion – Motion of an object about an axis

Examples:

- Basketball spinning on a finger
- Skater rotating during a spin
- Rotation of a bicycle wheel

Angular Position

Angular position is the rotational analogue of linear position.
It measures **how far** the body has rotated from a reference position.

- The angle θ is measured **counterclockwise** from the positive x-axis by convention.

- Angular position can be expressed in **degrees (°), radians (rad), or revolutions**.

Angular Displacement

Angular displacement is the change in angular position of a rotating line.
It is a **vector quantity**.

- SI unit: **radian (rad)**

- **Counterclockwise** displacement → **positive**

- **Clockwise** displacement → **negative**

One complete revolution:

$$\theta = 2\pi \text{ rad}$$

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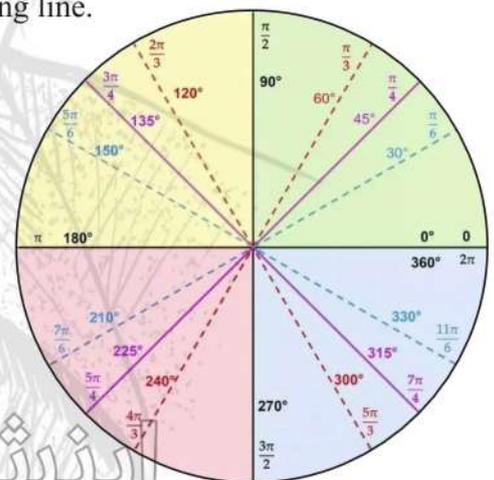
Measuring Revolution

A revolution can be **measured** in:

- **Degrees** → 360° = 1 rev

- **Radians** → 2π rad = 1 rev

Units of Angular Displacement

Angular displacement can be expressed in **3** units:

1. **Radian (rad)** — SI unit

2. **Degree (°)** — 1 full turn = 360°

3. **Revolution (rev)**
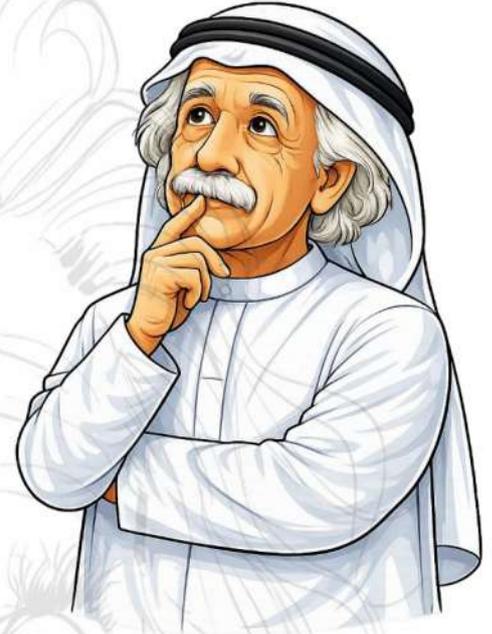
Radian–Degree Conversion

To convert from rad → degree

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

To convert from degree → rad

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

Revolution (rev)

A **revolution (rev)** represents **one complete rotation** around a circle.
Because one full rotation corresponds to an angle of:

$$360° = 2\pi \text{ rad} = 1 \text{ rev}$$

Conversion Between rev and rad

1. From Revolution to Radians

$$Radians = rev \times 2\pi$$

2. From Radians to Revolutions

$$rev = \frac{radians}{2\pi}$$

أ/ عبدالرحمن عصام عيد

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Check Your Understanding

1. Fill in the missing values. **Convert** each angle from **degrees to radians** and from **radians to degrees**.

	Degrees (°)	32°	95°	217°	—	—	12°	—	—
Angle	Radians (rad)				π	$\frac{\pi}{5}$	—	3 rad	2.4 rad

2. Which of the following is a unit used to measure an object's **rotation**?

   ⓐ Meter   ⓑ Newton   ⓒ Radian   ⓓ Kilogram

3. **Angular displacement** is the change in an object's ____ as it rotates.

   ⓐ orbit   ⓑ angle   ⓒ velocity   ⓓ acceleration

4. One **complete revolution** (360°) is equal to _____.

   ⓐ $\frac{\pi}{4}$ radians   ⓑ $\frac{\pi}{2}$ radians   ⓒ π radians   ⓓ 2π radians

5. The **radian** is a unit of angular measurement and is equal to approximately ____ degrees.

   ⓐ 30°   ⓑ 57°   ⓒ 60°   ⓓ 180°

6. A degree is a unit of measurement equal to:

   ⓐ $\frac{1}{360}$ of a revolution   ⓑ $\frac{1}{500}$ of a revolution   ⓒ $\frac{1}{2\pi}$ of a revolution   ⓓ $\frac{1}{4}$ of a revolution

7. The Earth rotates a total of how many radians in 24 hours?

   ⓐ π rad   ⓑ $\frac{\pi}{2}$ rad   ⓒ 2π rad   ⓓ 4π rad

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

   ⓐ $-\pi$ rad   ⓑ π rad   ⓒ 2π rad   ⓓ -2π rad

اينشتاين في الفيزياء

استاذ عبدالرحمن عصام عيد

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Angular displacement:

$$\Delta\theta = \theta_f - \theta_i$$

Note:

Angles measured CW are **negative**, and angles measured CCW are **positive**.
θ is measured in **radians**.
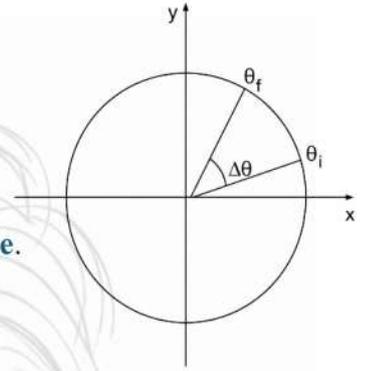
$$2\pi \text{ radians} = 360° = 1 \text{ revolution}$$

Check Your Understanding

9. What is the **angular displacement**?

    ⓐ The rate of change of angular velocity   ⓑ The change in the angle for a rotating body
    ⓒ The change in linear velocity of an object   ⓓ The change in the direction of angular velocity

10. A bike wheel rotates **4.50** revolutions. How many **radians** has it rotated?

    ⓐ 4.5 rad   ⓑ 7.0 rad   ⓒ 0.08 rad   ⓓ 28.3 rad

11. A wheel with a radius of **50 cm** is rotating.
    If the wheel completes **two full revolutions**, **how many radians** has it turned through?

    ⓐ 3πradians   ⓑ 4πradians   ⓒ πradians   ⓓ 2πradians

12. A wheel rotated **7.50** revolutions and then stopped.
    How many radians has it rotated?

    ⓐ 1.2 rad   ⓑ 7.5 rad   ⓒ 23.6 rad   ⓓ 47.1 rad

13. Einstein is rotating a ball around his finger.
    The ball rotated a total of **24.9 radians**.
    How many revolutions was that?

    ⓐ 15.0 revolutions   ⓑ 5.00 revolutions   ⓒ 2.50 revolutions   ⓓ 4.00 revolutions
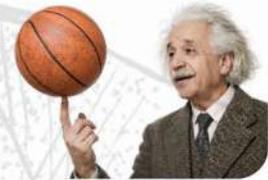
14. Mr Abdulrahman is walking around a circle in a counterclockwise motion.
    He moved $\frac{3\pi}{2}$**radians** and then rotated in the **opposite direction** for $\frac{\pi}{2}$**radians**.

    What is his **final angular displacement**?

    ⓐ $-\frac{3\pi}{2}$rad   ⓑ πrad   ⓒ $\frac{\pi}{4}$rad   ⓓ $-\frac{\pi}{2}$rad

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Measuring Distance

When an object rotates, a point located at a distance r from the center moves along a circular path.
The distance travelled by this point depends on:

- The **radius** r

- The **angular displacement** θ

The relationship between them is:

$$x = r\theta$$
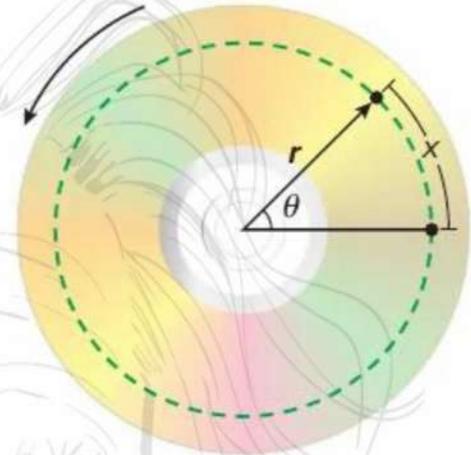
Where:

- x: linear distance (arc length)

- r: radius (distance from the center)

- θ: angular displacement (in radians)

always gives a distance in **meters**.

In case the angle is required

If the angle θ is requested, you can determine it using the relationship: $\theta = \dfrac{x}{r}$

Check Your Understanding

15. A point on a CD is located **4.0 cm** from the center of the disk.
If the disk begins to rotate and the point moves a **linear distance** of **12 cm**,
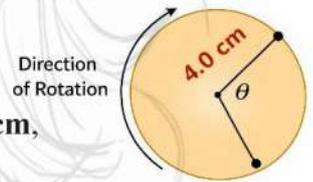
What is **the angular displacement** θ?

  ⓐ   3.0 rad   ⓑ   2.0 rad   ⓒ   1.0 rad   ⓓ   0.3 rad

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

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

17. Mr Abdulrahman is running around a circle with a radius of **2.00 m** in a clockwise motion. She completed **2.25 revolutions**.
What is the total distance she travelled?

  ⓐ   34.0 m   ⓑ   15.3 m   ⓒ   25.1 m   ⓓ   28.3 m

18. A car completes $\frac{3}{4}$ of a revolution turning counterclockwise around a roundabout.
The roundabout has a **radius of 12 m**. **What is the total distance** she travelled?

  ⓐ   19 m   ⓑ   75 m   ⓒ   28 m   ⓓ   57 m

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19. A point on a car tire rotated half a revolution in a clockwise motion.
    What is the angular displacement of that point?

    ⓐ $-\frac{\pi}{2}$rad   ⓑ $\frac{\pi}{2}$rad   ⓒ πrad   ⓓ $-\pi$rad

20. Ahmed tied a **0.750 m** string to a ball and rotated it **5.00 complete revolutions**.

    What is the total distance that the ball rotated?

    ⓐ 50.3 m   ⓑ 23.6 m   ⓒ 4.71 m   ⓓ 7.50 m

21. A point on the outer edge of a lucky wheel moves **31.4 m**, and the **diameter** of the wheel
    is **1.00 m**. **How many revolutions does the lucky wheel complete?**

    ⓐ 20.0 revolutions   ⓑ 5.00 revolutions   ⓒ 1.00 revolution   ⓓ 10.0 revolutions

22. A group of **boys** are holding hands in a circle of radius **r = 1.5 m**.

    What is the total distance covered by one boy after 5.0 revolutions?

    ⓐ 74 m   ⓑ 9.4 m   ⓒ 47 m   ⓓ 4.9 m

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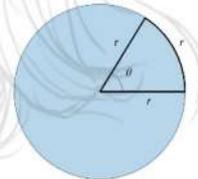
    What is the measure of the angle θ?

    ⓐ 30°   ⓑ 57°   ⓒ 60°   ⓓ 180°

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

    ⓐ 48 m   ⓑ 480 m   ⓒ 47 m   ⓓ 470 m

25. 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, as shown in the figure. what angle (in radians) is the wheel rotated?

26. A steering wheel is rotated through 128°, as shown in the figure. Its radius is 22 cm.

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

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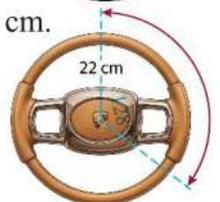
Angular Velocity

1. Linear Motion Reminder

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

2. Definition of Angular Velocity

The angular velocity of an object is the **angular displacement divided by the time taken** to make the angular displacement.

Angular velocity is represented by:

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

$$v = \frac{\Delta x}{\Delta t}$$

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

$$\theta = x/r$$

Where:

- $\omega =$ angular velocity
- $\Delta\theta = \theta_f - \theta_i$
- $\Delta t = t_f - t_i$

Angular velocity is measured in **rad/s**.

3. Sign Conventions

- **Counterclockwise (CCW)** → Positive angular velocity
- **Clockwise (CW)** → Negative angular velocity

27. Calculate the angular speed in the following cases:

a)

$$\theta_i = 1.0 \text{ rad}, \theta_f = 3.6 \text{ rad}, t_i = 30.0 \text{ s}, t_f = 50.0 \text{ s}$$

b)

$$\theta_i = 0.10 \text{ rad}, \theta_f = 2.0 \text{ rad}, t_i = 0.00 \text{ s}, t_f = 50.0 \text{ s}$$

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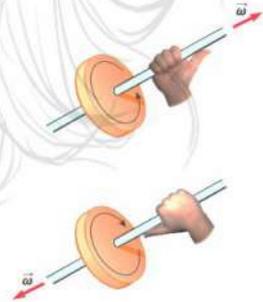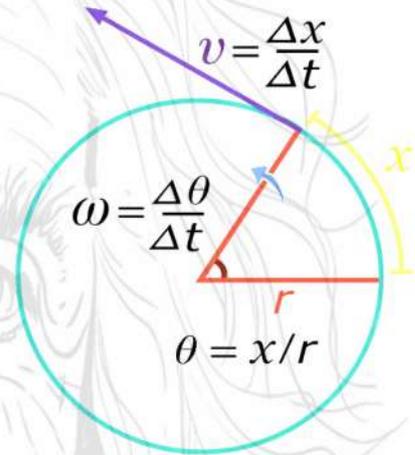
Linear Speed (Tangential Speed)

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

Even though all points share the **same angular velocity**, they do **not** move the same **linear distance**.

The **linear speed** of that point is called **tangential speed**, and it tells you how fast the point moves along the curved path.

Formula

$$v = r\omega$$

Where:

- v = linear (tangential) speed
- r = distance from the center (radius)
- ω = angular velocity (rad/s)
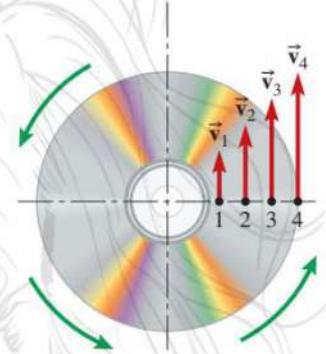
Note: Linear Speed is Directly Proportional to Radius

A point that is farther from the center moves **faster linearly** than a point closer to the center, even though both rotate with the same angular velocity.

28. A rotating disc has a knob on the edge. The disc completes one rotation every 3.0 s.

Using this information, you can calculate the angular _____ of the knob.
- (a) Acceleration
- (b) Displacement
- (c) Speed
- (d) revolution

29. If an object rotates **counterclockwise**, its **angular velocity** is _____.
- (a) Positive
- (b) Negative
- (c) Zero
- (d) Infinite

30. A cylinder of radius **0.7 m** rotates at **10 rad/s**. What is **the linear speed** of point P?
- (a) 7π rad/s
- (b) 14π rad/s
- (c) 7.0 m/s
- (d) 0.70 m/s

31. A CD has radius 6.0 cm and angular velocity **5.0 rad/s**.
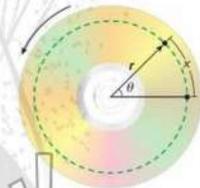
A-What is the angular displacement in 2.0 s?
- (a) 0.60 rad
- (b) 1.7 rad
- (c) 10 rad
- (d) 60 rad

B-What is the linear displacement in 2.0 s?
- (a) 0.60 m
- (b) 0.30 m
- (c) 3.8 m
- (d) 60 m

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32. A car travels around a roundabout in **25** s. Its **angular displacement is 2.9 rad**. What is the car's **average angular velocity** during this motion?

    ⓐ   73 rad/s   ⓑ   0.12 rad/s   ⓒ   3.0 rad/s   ⓓ   8.6 rad/s

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

    ⓐ   3.49 rad/s   ⓑ   1.75 rad/s   ⓒ   0.29 rad/s   ⓓ   209 rad/s

34. Which of the following is equivalent to **5000 rpm** (revolutions per minute)?

    ⓐ   524 rad/s   ⓑ   420 rad/s   ⓒ   240 rad/s   ⓓ   120 rad/s

35. If an object completes **one full revolution (360°)** in **2** seconds.

what is its **angular velocity** in rad/s?

    ⓐ $\frac{3}{4}\pi$ rad/s   ⓑ $\frac{1}{2}\pi$ rad/s   ⓒ 2π rad/s   ⓓ π rad/s

36. The figure shows two touching gears. One gear is larger than the other. Which quantity is the **same** for both gears?

    ⓐ   Linear speed   ⓑ   Angular speed   ⓒ   Angular displacement   ⓓ   Angular acceleration

37. In the clock shown in the figure, all parts of the minute hand are equal in _____ .

    ⓐ   Linear speed   ⓑ   Angular speed   ⓒ   Angular displacement   ⓓ   Angular acceleration

38. The figure shows a rotating disk with two spots on it: **A** and **B**. Spot **A** is at a distance **(X) cm** from the disk's center, and spot **B** is at a distance **(Y) cm** from the center.

How can the angular velocities of the two spots be compared?
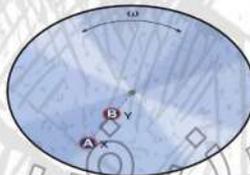
    ⓐ   The angular velocity of spot (B) will be greater than spot (A).   ⓑ   The angular velocity of spot (A) will be greater than spot (B).

    ⓒ   The angular velocity of both spots will be zero.   ⓓ   The angular velocity of both spots will be equal and non-zero.

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39. A kitchen blender rotates at **200 revolutions per minute (200 RPM)** as shown in the figure.

   1. **What is the angular speed** of the blender in rad/s?

   2. **How many radians** does the blender rotate in 5 seconds?

   3. **How many complete revolutions** does it make in 5 seconds?

   ....
   ....
   ....

40. The outer edge of a truck tire that has a radius of 45 cm has a velocity of 23 m/s.

   What is **the angular velocity** of the tire in rad/s?

   ....
   ....
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41. An automobile wheel with a 9.00 cm radius, as shown in the figure, rotates at 2.50 rad/s.

   How **fast** does a point 7.00 cm from the center travel?

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Earth's Angular Velocity

1. Angular Velocity of Earth

Angular velocity is measured in **rad/s**.
Earth completes **one full rotation (2π rad)** in **24 hours**.

$$\omega_E = \frac{2\pi \text{ rad}}{24.0 \text{ h} \times 60 \times 60 \text{ s/h}} = 7.27 \times 10^{-5} \text{ rad/s}$$

This value represents how fast Earth rotates about its axis.

2. Direction of Earth's Angular Velocity

Just like any rotational motion:

- **Counterclockwise rotation → positive angular velocity**

- Earth rotates counterclockwise when viewed from above the North Pole, so its angular velocity is **positive**

3. Linear Speed Due to Earth's Rotation

If an object has angular velocity ω, then any point at radius r from the axis moves with linear speed:

$$v = r\omega$$

Earth's radius is:

$$r = 6.38 \times 10^6 \text{ m}$$

So the linear (tangential) speed at the equator is:

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

4. Rigid Body Rotation

Earth behaves like a **rotating rigid body**:

- Points at different latitudes do **not** travel the same distance per rotation.

- But all points rotate through the **same angle** in the same time.

- Therefore, all parts share the **same angular velocity**.

Note:

- Most objects in this chapter are treated as **rigid bodies**.

- The Sun is **not** a rigid body; different parts rotate at **different angular velocities**.

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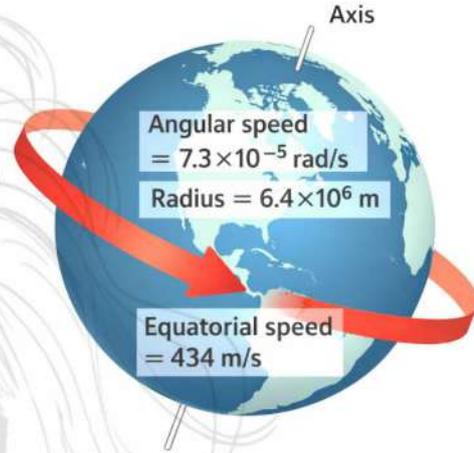
Angular Acceleration

1. Definition

Angular acceleration is the **rate of change of angular velocity** with respect **to time**.

It describes how quickly an object speeds up or slows down while rotating.

$$\Delta\omega = \omega_f - \omega_i \qquad\qquad \alpha = \frac{\Delta\omega}{\Delta t}$$

Where:

- α = angular acceleration
- ω = angular velocity
- t = time

2. Sign Convention

- **Positive angular acceleration (+α):**
  When the angular velocity increases in the **counterclockwise** direction.

- **Negative angular acceleration (−α):**
  When the angular velocity decreases or when rotation is **clockwise**.

3. Units: Angular acceleration is measured in: rad/s^2

42. 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/s²   (b) 4 rad/s²   (c) 3 rad/s²   (d) 2 rad/s²

43. 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/s²   (b) 0.921 rad/s²   (c) 0.740 rad/s²   (d) 0.360 rad/s²

44. A blender blade spins from rest to 9000 rev/min in 4.5 s.

What is **the angular acceleration** in rad/s²?

(a) 756 rad/s²   (b) 2000 rad/s²   (c) 12.6 rad/s²   (d) 209 rad/s²

45. A CD starts rotating from rest and reaches an angular speed of 6π rad/sin 3.0 s.
What is **the angular acceleration** of the CD?

(a) 6π rad/s²   (b) 4π rad/s²   (c) 2π rad/s²   (d) π rad/s²

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46. A centrifuge rotor is accelerated for **20 s** from rest to **10,000 rpm**. What is its **average angular acceleration**?

    ⓐ 558 rad/s²   ⓑ 17.3 rad/s²   ⓒ 1050 rad/s²   ⓓ 52.5 rad/s²

47. A merry-go-round has an angular acceleration of 0.30 rad/s². After accelerating from rest for **2.8 s, what angle** (in radians) does the merry-go-round rotate?

    ⓐ 8.0 rad   ⓑ 2.0 rad   ⓒ 2.4 rad   ⓓ 1.2 rad

48. Angular ___ is equal to the change in angular velocity divided by the time required to make that change.

    ⓐ displacement   ⓑ acceleration   ⓒ velocity   ⓓ Frequency

49. Which of the following is **not** true?

    ⓐ Angular acceleration increases when the torque increases.
    ⓑ Angular acceleration increases when the moment of inertia decreases.
    ⓒ Angular acceleration decreases when the moment of inertia increases.
    ⓓ Angular acceleration decreases when the torque increases.

50. Which of the following statements is **true** regarding angular displacement and angular velocity?

    ⓐ Angular displacement is always constant.
    ⓑ Angular displacement and angular velocity are dependent on each other.
    ⓒ Angular displacement is always equal to angular velocity.
    ⓓ Angular displacement and angular velocity are independent of one another.

51. A car wheel turns from rest to 4.75 rad/sin 2.25 s. Calculate **the angular acceleration** of the wheel.

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52. The wheels of a car initially rotating with an angular speed of 3.0 rad/sincrease their speed to 15 rad/sin 6.0 s. What is the **angular acceleration** of the wheels?

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Rotational Motion
Lesson 1: Describing Rotational Motion

Main words
Rotational Motion · Angular Displacement linear distance (arc length)
Angular Velocity · Angular Acceleration · Angular Frequency

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53. A grindstone has an **angular acceleration of 0.27 rad/s²** and an **initial angular velocity of −3.3 rad/s**. **How long** does it take to stop momentarily?

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Relation Between Linear and Angular Quantities

Quantity	Linear	Angular	Relationship
Displacement	x(m)	θ(rad)	$x = r\theta$
Velocity	v(m/s)	ω(rad/s)	$v = r\omega$
Acceleration	a(m/s²)	α(rad/s²)	$a = r\alpha$

Angular Frequency

1. Definition

Angular frequency is the **number of complete revolutions** an object makes in **1 second**.

It is given by the formula:

$$f = \frac{\omega}{2\pi}$$
$$\omega = 2\pi f$$

Where:

f = angular frequency (rev/s) ω = angular velocity (rad/s)

Note: The period T is equal to the reciprocal of the angular frequency. $T = \frac{1}{f}$

54. Which of the following is a **correct** relationship between linear displacement and angular displacement?

ⓐ $a = r\alpha$ ⓑ $v = r\omega$ ⓒ $x = r\theta$ ⓓ $v = \frac{d}{t}$

55. The angular **acceleration** of an object is given by:

ⓐ $v = r\omega$ ⓑ $d = r\theta$ ⓒ $\alpha = \frac{\Delta\omega}{\Delta t}$ ⓓ $\alpha = \frac{\Delta\theta}{\Delta t}$

56. If the linear acceleration of a truck is 1.85 m/s² and the angular acceleration of the wheels is 5.23 rad/s², what is the **radius** of the truck's wheels?

ⓐ 5.6 m   ⓑ 2.8 m   ⓒ 0.70 m   ⓓ 0.35 m

57. A roller coaster experiences a change in angular velocity of **2.4 rad/s** in **0.64 seconds**. **What is its average angular** acceleration?

ⓐ 4.6 rad/s²   ⓑ 3.8 rad/s²   ⓒ 2.4 rad/s²   ⓓ 1.6 rad/s²

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58. If the dashboard reading in Salem's car shows both the angular acceleration and the linear acceleration of the wheel, calculate the diameter of the wheel (in cm) using these readings:

$$\alpha = 68 \text{ rad/s}^2 \qquad a = 14 \text{ m/s}^2$$

What is the **diameter** of the circular wheel?

(a) 4.8 cm (b) 4.1 cm (c) 0.21 cm (d) 15 cm

59. Suppose a Ferris wheel in Dubai has a frequency of (0.1 Hz).
What is **the angular velocity** of the Ferris wheel in rad/s?

(a) 20π (b) 10π
(c) 0.1π (d) 0.2π

60. A car has linear acceleration 1.8 m/s² and wheel radius 0.33 m.

What is the **angular acceleration**?
(a) 5.5 rad/s² (b) 9.8 rad/s² (c) 0.59 rad/s² (d) 0.18 rad/s²

61. A flywheel (diameter 1.2 m) has angular acceleration 5.0 rad/s².

What is **the tangential acceleration** at the rim?

(a) 10 m/s² (b) 6.0 m/s² (c) 5.0 m/s² (d) 3.0 m/s²

62. A carousel is initially at rest. It rotates with a constant angular acceleration $\alpha = 0.06$ rad/s² and increases its angular velocity for **8.0 s** before becoming constant.
If the **linear speed** of a child riding a horse is **1.2 m/s**.

how far is the horse from the center?

(a) 1.0 m (b) 0.6 m (c) 1.2 m (d) 2.5 m

63. A Ferris wheel, as shown in the figure, completes one full revolution every 8 seconds.

What is the **angular velocity** of the Ferris wheel in **rad/s**?

(a) $\frac{2\pi}{3}$rad/s (b) $\frac{\pi}{8}$rad/s (c) $\frac{\pi}{4}$rad/s (d) $\frac{\pi}{2}$rad/s

64. A motor has an angular speed of **1200 rad/s. What is its frequency?**

(a) 150 Hz (b) 190 Hz (c) 300 Hz (d) 280 Hz

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65. A disk rotates with a frequency of 1.3 Hz. What is **the angular velocity** of the disk?

ⓐ   8.2 rad/s   ⓑ   7.4 rad/s   ⓒ   4.7 rad/s   ⓓ   2.4 rad/s

66. A car with tire radius 32 cm travels at 25 m/s. What is its **angular speed**?

ⓐ   78 rad/s   ⓑ   12 rad/s   ⓒ   8.0 rad/s   ⓓ   0.013 rad/s

67. A wheel in a mechanic's shop is being tested.
Its angular velocity increased from **450 rad/min** to **2500 rad/s** in **half a minute**.
What is the average angular acceleration?

ⓐ   83 rad/s²   ⓑ   68 rad/s²   ⓒ   25 rad/s²   ⓓ   250 rad/s²

68. A toy car is traveling around a circular track with a linear acceleration of 25 m/s².
The diameter of the track is 1.52m.
What is **the angular acceleration** in revolutions per second squared (rev/s²)?

ⓐ   7.9 rev/s²   ⓑ   5.2 rev/s²   ⓒ   1.5 rev/s²   ⓓ   3.8 rev/s²

69. A car is accelerating in a straight line. The wheels of the car rotate as the car speeds up.
You are given the following data:

- Diameter of each wheel: **76 cm**

- Change in the car's linear velocity: **25 m/s**

- Time taken for this change: **11 s**

What is the angular acceleration of the wheel?

ⓐ   7.9 rad/s²   ⓑ   2.8 rad/s²   ⓒ   6.0 rad/s²   ⓓ   4.6 rad/s²

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A ball moves along a circular path and travels an arc length of **30 cm** corresponding to a
central angle of **225°**. It took the ball **2 seconds** for this motion.
Answer the following:

1. **Calculate the radius** of the circular path.

2. **Determine the average angular velocity** of the ball.

3. **Find the linear (tangential) speed** of the ball.

$\theta = 225°$

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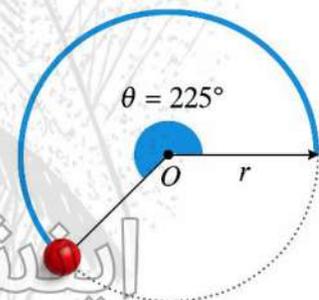
Practice Problems

1. Angular Displacement – Clock Hands

What is **the angular displacement** of each of the following hands of a clock in **10.0 h**? State your answer in three significant digits.

a. the second hand

b. the minute hand

c. the hour hand

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2. Rotating Toy Above Crib

A rotating toy above a crib makes one complete counterclockwise rotation in **1 min**.

a. What is its **angular displacement** in **3 min**?

b. What is **the toy's angular velocity** in **rad/min**?

c. If the toy is turned off, does it have **positive or negative angular** acceleration? Explain.

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3. Truck and Wheel Acceleration

If a truck has a linear acceleration of **1.85 m/s²** and the wheels have an angular acceleration of **5.23 rad/s²**, what is **the diameter of the wheels**?

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4. Trailer Wheels Comparison

The truck in the previous problem is towing a trailer with wheels that have a diameter of **48 cm**.

a. How does **the linear acceleration** of the trailer wheels compare to that of the truck wheels?

b. How does **the angular acceleration** of the trailer wheels compare to that of the truck wheels?

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5. CHALLENGE – Replacing Tires

If you replace the truck's tires with new tires of **larger diameter**, how does the angular velocity and number of revolutions change for trips at the same speed?

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Check Your Progress

6. Angular Velocity – The Moon

The Moon (radius $r = 1.74 \times 10^6$m) rotates once on its axis in **27.3 days**.

a. What is its **period** of rotation in seconds?

b. What is its **angular velocity** in **rad/s**?

c. A rock sits on the surface at the Moon's equator. What is its **linear speed**?

d. **Compare** this speed with that of a person at Earth's equator.

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7. Angular Displacement – Movie Length

A movie lasts **2 h**.

Calculate **the angular displacement** of:

a. the second hand

b. the minute hand

c. the hour hand

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8. Angular Acceleration – Spin Cycle

During the rinse spin cycle of a clothes washer, the drum turns at **8.0 rev/s** after accelerating from rest in **5.0 s**.

What is **the angular acceleration** of the drum?

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9. Angular Displacement – Watch Hands

Do **all parts** of the minute hand on a watch have **the same angular displacement**?

Do they **have the same linear displacement**?

Explain.

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10. Critical Thinking – CD-ROM Track

A CD-ROM has a spiral track that starts at **24 mm** from the center and ends at **55.5 mm**.
The disc spins once in **0.55 s**.
a. Find the linear velocity of the track at the inner and outer edges.
b. Find the angular velocity of the disk (in rad/s and rev/s).
c. Determine the angular acceleration of the disk if it plays for **76 min**.