

Types of motion with examples, and acceleration: positive, negative and zero

Type	What moves how	Examples
Translational	whole object moves from place to place	car, pushed book, lift, thrown ball
Rectilinear	along a straight line	train on straight track, falling apple, sprinter
Curvilinear	along a curve	thrown ball's arc, car on a bend, river
Rotational	spins about an axis	wheel, top, Earth on its axis, fan, drill
Oscillatory	to and fro about a rest position	pendulum, swing, guitar string, piston
Periodic	repeats at equal time intervals	Earth's orbit, heartbeat, clock hand, tides, any oscillation
Circular	around a circle (curvilinear and periodic)	satellite, stone on a string, fan-blade tip, roundabout
Random	no fixed path	a bee, smoke particles (Brownian), a football in play

Lists differ between textbooks; name the type and justify it. Real motions combine: a rolling wheel translates and rotates; the Earth rotates (a day) and revolves (a year); a sewing needle oscillates while its wheel rotates.

Acceleration: $a = (v - u) / t$, in m/s^2

	Velocity	(v - u)	Acceleration	Example
Positive	increasing in the + direction	+	speeding up	0 to 15 m/s in 5 s: $+3 m/s^2$
Negative (deceleration)	decreasing in the + direction	-	slowing down	20 m/s to 0 in 4 s: $-5 m/s^2$
Zero	constant	0	none; steady speed in a straight line	train at 30 m/s on straight track

[] Choose the positive direction first. Negative acceleration slows an object only if it moves in the positive direction: a ball thrown up (up +) has $a = -9.8 m/s^2$ all the way, slowing on the way up and speeding up on the way down; at the top $v = 0$ and a is still -9.8

[] Velocity is a vector, so a change of direction is an acceleration: a car on a bend at steady speed, a satellite in orbit (acceleration toward the centre)

[] Free fall: $9.8 m/s^2$ down; a dropped stone gains $9.8 m/s$ of speed every second

Worked

[] Cyclist 4 to 10 m/s in 3 s: $2 m/s^2$

[] Train 40 to 25 m/s in 30 s: $-0.5 m/s^2$

[] Stone dropped: after 3 s, $v = 9.8 \times 3 = 29.4 m/s$

[] Ball up at 19.6 m/s: time to top = $19.6 / 9.8 = 2 s$

[] Car at constant 20 m/s for 10 s: $a = 0$, distance 200 m

[] Sprinter 0 to 11 m/s in 2.5 s then steady: $4.4 m/s^2$ then 0

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The motion graphs, uniform motion, the mistakes, and a practice set

Distance-time graph	Velocity-time graph
flat line: at rest	flat line above zero: constant velocity, $a = 0$
straight slope: constant speed; gradient = speed	straight slope up: constant acceleration; gradient = acceleration
curve steepening: speeding up; flattening: slowing	slope down: negative acceleration (slowing if above the axis)
never slopes down (displacement-time can: returning)	AREA under the graph = distance travelled

Worked: v rises 0 to 12 m/s in 4 s, holds 6 s, falls to 0 in 2 s. Accelerations 3, 0, -6 m/s². Distance = $\frac{1}{2} \times 4 \times 12 + 6 \times 12 + \frac{1}{2} \times 2 \times 12 = 24 + 72 + 12 = 108$ m. Read the axis label before the shape: a slope on d-t is steady speed; a slope on v-t is steady acceleration.

	Uniform motion	Non-uniform motion
Definition	equal distances in equal times	unequal distances in equal times
Speed; acceleration	constant; zero	changing; not zero
d-t graph	straight slope	curve
Example	cruise control on a straight road	bus in traffic, falling stone

Mistakes

- [] Speed and velocity treated as the same word
- [] Negative acceleration always means slowing; zero velocity means zero acceleration
- [] A sloping d-t line read as acceleration; distance read off a v-t graph instead of the area
- [] m/s written for acceleration (it is m/s²); 'rotation' for the Earth's orbit (revolution)

Practice

- Name the type(s) of motion of: a ceiling fan, a child on a swing, a car on a straight road, a rolling football, the Moon around the Earth.
- A motorbike goes from 5 to 25 m/s in 8 s. Acceleration?
- A bus slows from 15 to 3 m/s in 6 s. Acceleration, and the word for it?
- A ball is thrown straight up at 14.7 m/s. Time to the top; velocity and acceleration there?
- A v-t graph is flat at 8 m/s for 5 s. Acceleration and distance?
- Why is a car on a roundabout at a steady 20 km/h accelerating?

Answers

- Rotational; oscillatory (periodic); rectilinear translational; translational + rotational; circular (periodic, curvilinear).
- 2.5 m/s².
- 2 m/s²; deceleration (retardation).
- 1.5 s; $v = 0$, $a = -9.8$ m/s².
- 0; 40 m.
- Its direction, and so its velocity, is changing; the acceleration points toward the centre of the roundabout.