

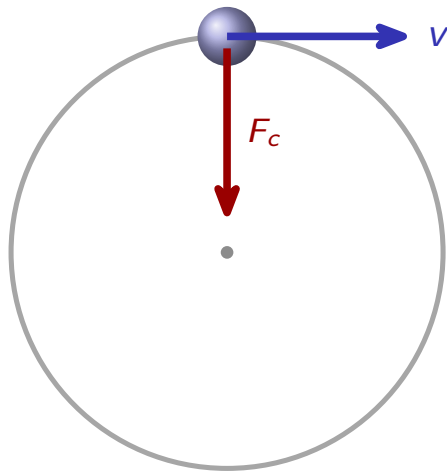
Exercise walk-through

2.9

Circular Motion

AP Physics 1

Uniform circular motion



Uniform circular motion :
steady speed, changing direction – so it
accelerates.

Toward the center

$$a_c = \frac{v^2}{r}, \quad F_c = \frac{mv^2}{r}$$

Centripetal force is a **role**
– filled by tension, gravity, or friction. Cut it, and the object flies off straight.

Uniform circular motion, in its own words

Period and frequency

The **period** T is the time for one revolution; the **frequency** $f = 1/T$ is revolutions per second.

Speed

$v = \frac{2\pi r}{T}$ – one circumference in one period.

Centripetal acceleration

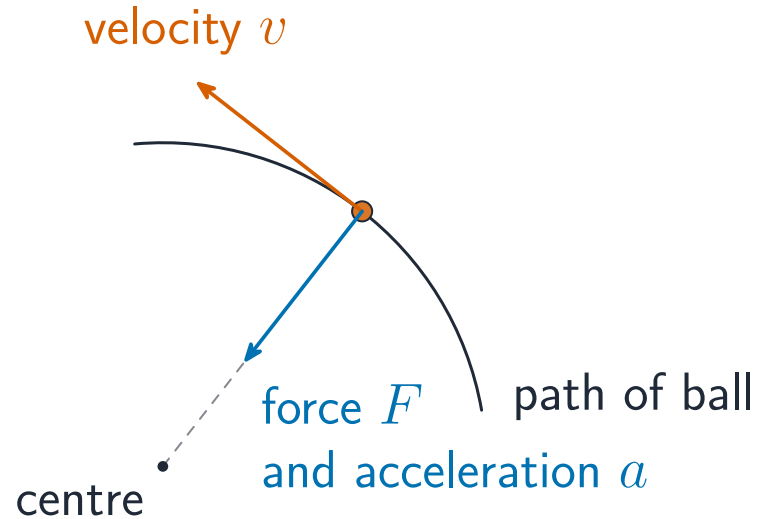
Centripetal acceleration $a_c = \frac{v^2}{r}$, directed towards the centre.
The speed is constant; the velocity is not.

The force

$F_{net} = ma_c$, supplied by whatever actually points inward – tension, friction, gravity, the normal force.

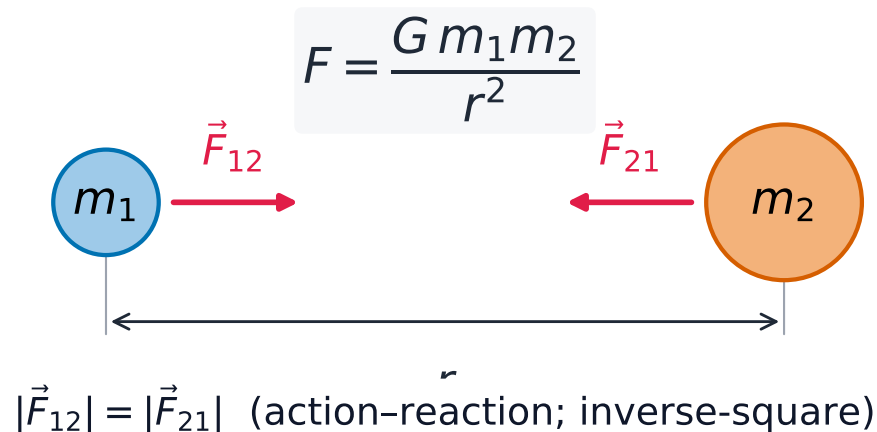
“Centripetal force” is a *role*, never a new force. Name the real force filling it, or the free-body diagram is wrong.

Circular Motion



The velocity points along the tangent; the centripetal force and acceleration point to the centre

Gravitational Force, continued



Two masses attract each other with equal, opposite, inverse-square forces along the line joining them

Mass plays two distinct roles

inertial mass

how strongly an object **resists acceleration** – the m in $F = ma$

gravitational mass

how strongly it **attracts and is attracted** – the m in the law of gravitation

the remarkable fact

experiment finds them **equal**, to extraordinary precision

the consequence

all objects fall with the same acceleration, because the extra weight is exactly cancelled by the extra inertia

Newton's law of gravitation

$$F = \frac{Gm_1 m_2}{r^2}$$

gravitational field strength

$g = \frac{GM}{r^2}$ – force per unit mass, and numerically the free-fall acceleration

That the two masses are equal is why Galileo's result holds. It is an experimental fact, not a definition – and Einstein made it the starting point of general relativity.

Exercises 2.1-2.3

2.1 A ball moves at 4.0 m s^{-1} in a circle of radius 2.0 m . Find its centripetal acceleration. [2]

2.2 Name the force that keeps a car moving around a flat circular track. [1]

2.3 A 0.50 kg ball moves in a circle with centripetal acceleration 8.0 m s^{-2} . Find the centripetal force. [1]

Exercises 2.1·2.3

2.1 A ball moves at 4.0 m s^{-1} in a circle of radius 2.0 m . Find its centripetal acceleration. [2]

2.1

- $$a_c = \frac{v^2}{r} = \frac{4.0^2}{2.0} = 8.0 \text{ m s}^{-2}$$

2.2 Name the force that keeps a car moving around a flat circular track. [1]

2.2

- friction (between the tyres and the road)

2.3 A 0.50 kg ball moves in a circle with centripetal acceleration 8.0 m s^{-2} . Find the centripetal force. [1]

2.3

- $$F_c = ma_c = 0.50 \times 8.0 = 4.0 \text{ N}$$

Exercises 2.4·3.1

2.4 An object completes a circle in 0.25 s. Find its frequency.

[1]

3.1 For an object in uniform circular motion, the net force points

[1]

☐

A along the velocity

B opposite the velocity

C toward the centre

D away from the centre

Exercises 2.4·3.1

2.4 An object completes a circle in 0.25 s. Find its frequency. [1]

2.4

- $f = \frac{1}{T} = \frac{1}{0.25} = 4.0 \text{ Hz}$

3.1 For an object in uniform circular motion, the net force points [1]

☐

A along the velocity

B opposite the velocity

C toward the centre

D away from the centre

3.1 C

- toward the centre.

Exercise 3.2

3.2 If the speed of an object in a circle doubles (same radius), the centripetal acceleration becomes [1]

☐

A unchanged

B twice as large

C four times as large

D half as large

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☐

A unchanged

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3.2 C

- $a_c \propto v^2$

Exercise 3.3 (a)

3.3 A 0.20 kg ball on a string moves in a horizontal circle of radius 0.50 m at 3.0 m s^{-1} .

(a) Find the centripetal acceleration. [2]

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(a)

- $$a_c = \frac{3.0^2}{0.50} = 18 \text{ m s}^{-2}$$

Exercise 3.3 (b)

3.3 A 0.20 kg ball on a string moves in a horizontal circle of radius 0.50 m at 3.0 m s^{-1} .

(b) Find the tension in the string (the centripetal force). [2]

Exercise 3.3 (b)

3.3 A 0.20 kg ball on a string moves in a horizontal circle of radius 0.50 m at 3.0 m s^{-1} .

(b) Find the tension in the string (the centripetal force). [2]

(b)

- $F_c = ma_c = 0.20 \times 18 = 3.6 \text{ N}$