

Exercise walk-through

2.10

Circular Motion

AP Physics C: Mechanics

Circular motion

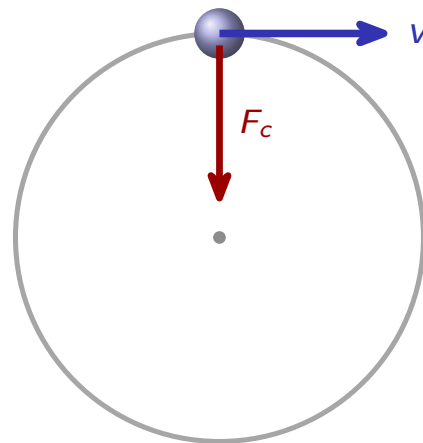
Uniform circular motion

steady speed, changing direction – so it accelerates toward the centre:

Centripetal quantities

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

Non-uniform motion also has a **tangential** force that changes the speed.



A car needs F_c from tyre friction – else it skids.

Circular motion needs a net inward force

centripetal acceleration

$$a_c = \frac{v^2}{r} = \omega^2 r, \text{ always pointing to the centre}$$

the force

$$F_c = \frac{mv^2}{r} - \text{not a new force. It is the name for whatever the net inward force already is}$$

identify it

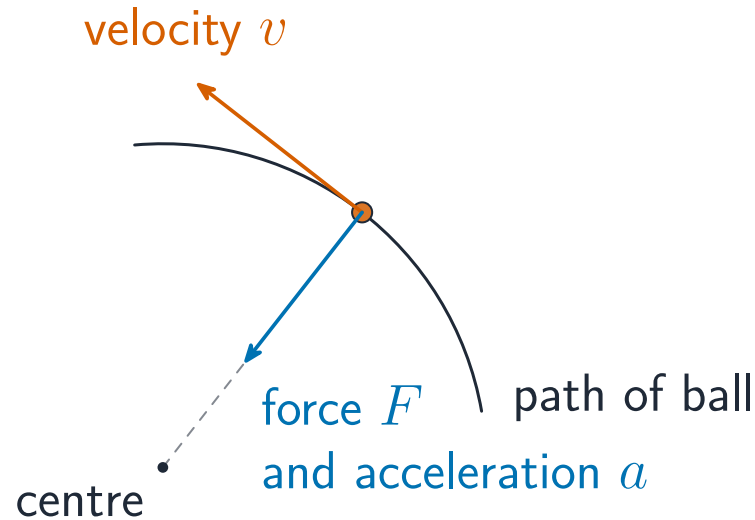
tension, gravity, friction, the normal force – say *which*, every time

Newton's law of gravitation

$$F = \frac{Gm_1 m_2}{r^2} - \text{the inward force for an orbit}$$

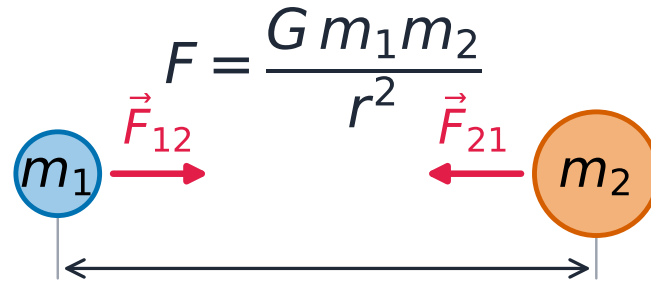
There is no outward force. Writing 'centrifugal force' on a free-body diagram loses the mark; the sensation of being flung out is the body's **inertia**, not a force.

The velocity points along the tangent; the acceleration inward



The velocity points along the tangent; the centripetal force points to the centre

Gravitational Force

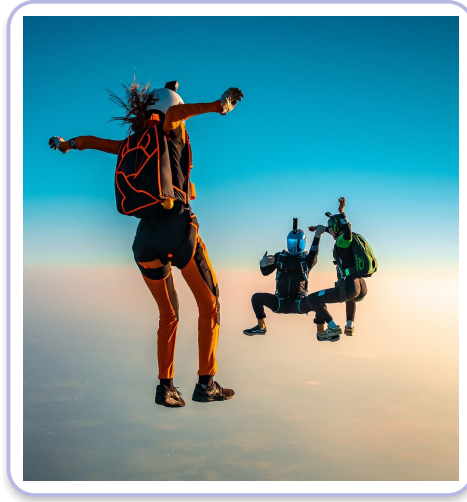


$$\vec{F}_{12} = -\vec{F}_{21} \text{ (third-law pair; equal magnitude, opposite direction)}$$

$$F = Gm_1m_2/r^2 \quad \cdot \quad g = GM/r^2 \text{ outside sphere}$$

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

Resistive Forces



Skydivers in freefall: drag grows with speed until it balances weight at terminal velocity

Exercises 2.1-2.3

2.1 State the direction of the centripetal acceleration. [1]

2.2 A 3 kg ball moves in a circle of radius 2 m at 4 m s^{-1} . Find the centripetal force. [2]

2.3 Name the force that keeps a car turning on a flat road. [1]

Exercises 2.1-2.3

2.1 State the direction of the centripetal acceleration. [1]

2.1

- Toward the centre of the circle
-

2.2 A 3 kg ball moves in a circle of radius 2 m at 4 m s^{-1} . Find the centripetal force. [2]

2.2

- $$F_c = \frac{mv^2}{r} = \frac{3(4)^2}{2} = 24 \text{ N}$$

2.3 Name the force that keeps a car turning on a flat road. [1]

2.3

- Friction (between the tyres and the road)

Exercises 2.4·3.1

2.4 An object has $v = 6 \text{ m s}^{-1}$ and $r = 3 \text{ m}$. Find its centripetal acceleration. [2]

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

☐

A along the velocity

B toward the centre

C away from the centre

D upward

Exercises 2.4·3.1

2.4 An object has $v = 6 \text{ m s}^{-1}$ and $r = 3 \text{ m}$. Find its centripetal acceleration. [2]

2.4

- $a_c = \frac{v^2}{r} = \frac{6^2}{3} = 12 \text{ m s}^{-2}$

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

☐

A along the velocity

B toward the centre

C away from the centre

D upward

3.1 B

- the centripetal force points toward the centre

Exercise 3.2

3.2 Doubling the speed of an object in a fixed circle changes the centripetal force by a factor of [1]

☐

A 2

B 4

C $1/2$

D 1

Exercise 3.2

3.2 Doubling the speed of an object in a fixed circle changes the centripetal force by a factor of [1]

☐

A 2

B 4

C 1/2

D 1

3.2 B

- $F_c \propto v^2$, so doubling v gives $2^2 = 4$ times

Exercise 3.3 (a)

3.3 A 0.5 kg ball on a string moves in a horizontal circle of radius 1 m at 3 m s^{-1} .

(a) Find the centripetal force.

[2]

Exercise 3.3 (a)

3.3 A 0.5 kg ball on a string moves in a horizontal circle of radius 1 m at 3 m s^{-1} .

(a) Find the centripetal force.

[2]

(a)

- $$F_c = \frac{0.5(3)^2}{1} = 4.5 \text{ N}$$

Exercise 3.3 (b)

3.3 A 0.5 kg ball on a string moves in a horizontal circle of radius 1 m at 3 m s^{-1} .

(b) State what provides this force.

[1]

Exercise 3.3 (b)

3.3 A 0.5 kg ball on a string moves in a horizontal circle of radius 1 m at 3 m s^{-1} .

(b) State what provides this force.

[1]

(b)

- The tension in the string

Exercise 3.4 (a)

3.4 A car of mass 1000 kg rounds a curve of radius 50 m at 10 m s^{-1} .

(a) Find the centripetal acceleration.

[2]

Exercise 3.4 (a)

3.4 A car of mass 1000 kg rounds a curve of radius 50 m at 10 m s^{-1} .

(a) Find the centripetal acceleration.

[2]

(a)

- $a_c = \frac{10^2}{50} = 2 \text{ m s}^{-2}$

Exercise 3.4 (b)

3.4 A car of mass 1000 kg rounds a curve of radius 50 m at 10 m s^{-1} .

(b) Find the friction force needed to keep it on the curve.

[1]

Exercise 3.4 (b)

3.4 A car of mass 1000 kg rounds a curve of radius 50 m at 10 m s^{-1} .

(b) Find the friction force needed to keep it on the curve.

[1]

(b)

- $F = ma_c = 1000 \times 2 = 2000 \text{ N}$