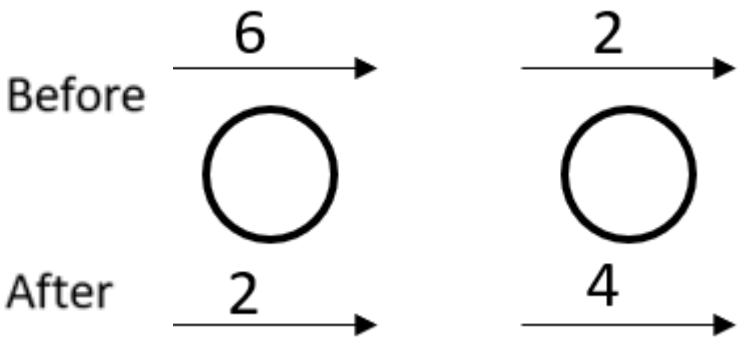
4.1) Direct impact and Newton's law of restitution

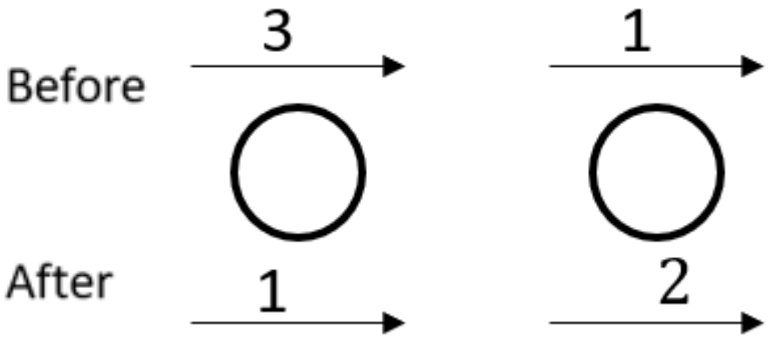
Worked example

Calculate the value of the coefficient of restitution, e, in the isolated system:



Your turn

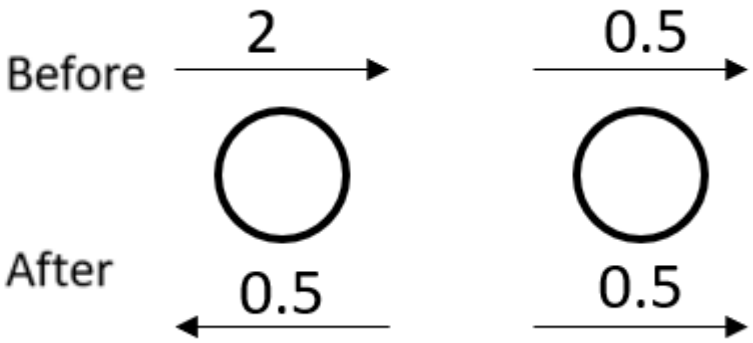
Calculate the value of the coefficient of restitution, e, in the isolated system:



$e = \frac{1}{2}$

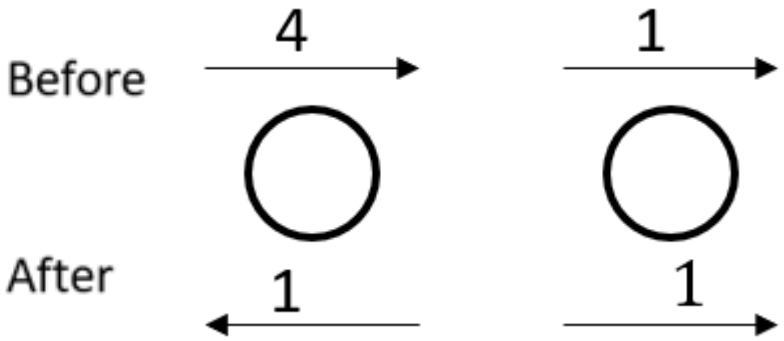
Worked example

Calculate the value of the coefficient of restitution, e, in the isolated system:



Your turn

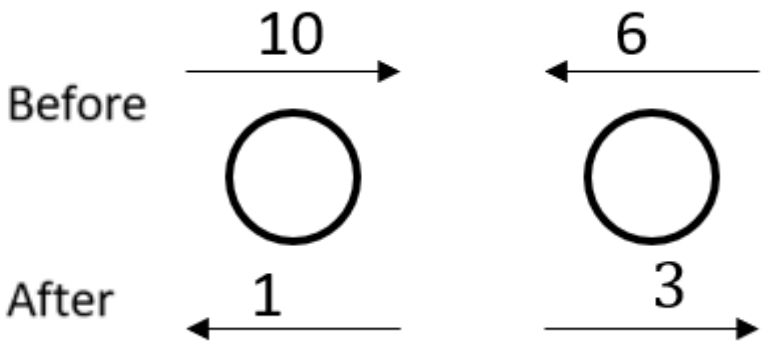
Calculate the value of the coefficient of restitution, e, in the isolated system:



$$e = \frac{2}{3}$$

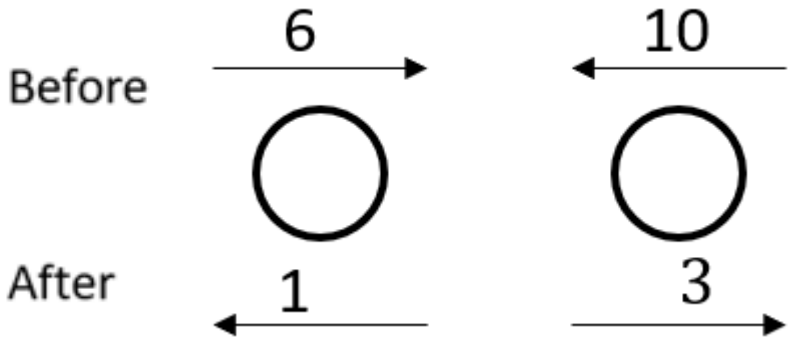
Worked example

Calculate the value of the coefficient of restitution, e, in the isolated system:



Your turn

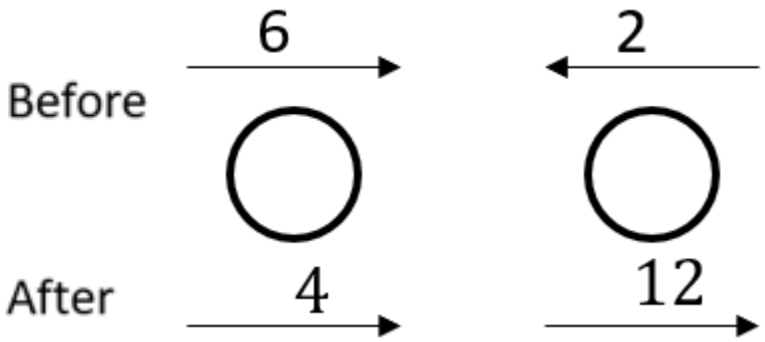
Calculate the value of the coefficient of restitution, e, in the isolated system:



$$e = \frac{1}{4}$$

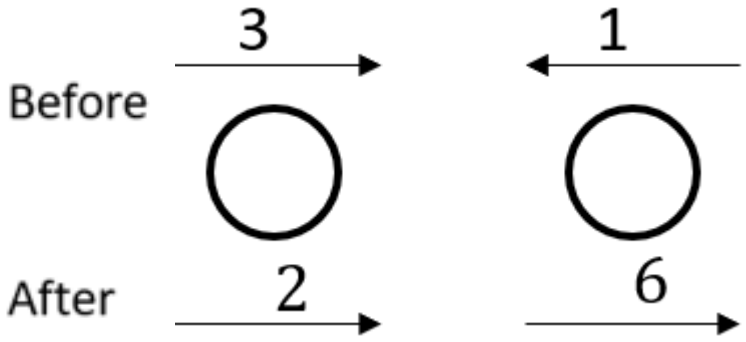
Worked example

Calculate the value of the coefficient of restitution, e, in the isolated system:



Your turn

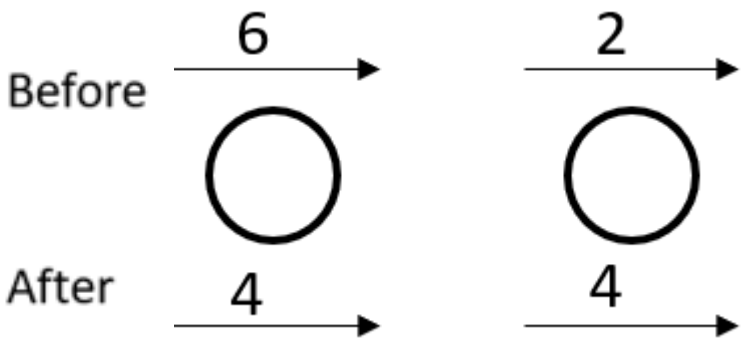
Calculate the value of the coefficient of restitution, e, in the isolated system:



$e = 1$; Perfectly elastic

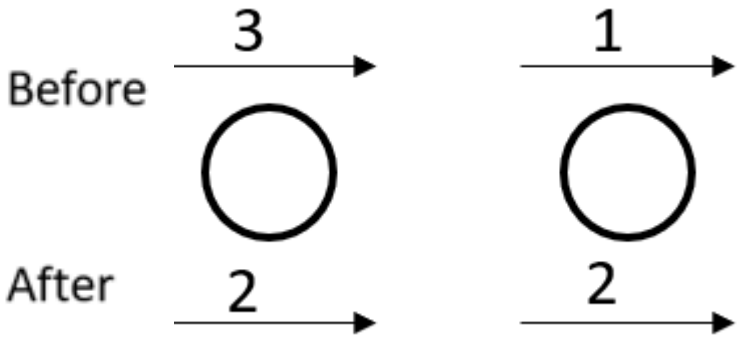
Worked example

Calculate the value of the coefficient of restitution, e, in the isolated system:



Your turn

Calculate the value of the coefficient of restitution, e, in the isolated system:



$e = 0$; Totally inelastic ; Particles coalesce

Worked example

Two particles A and B are travelling in the same direction on a smooth surface with speeds $8\ ms^{-1}$ and $6\ ms^{-1}$ respectively.
They collide directly, and immediately after the collision continue to travel in the same direction with speeds $4\ ms^{-1}$ and $v\ ms^{-1}$ respectively.
Given that the coefficient of restitution between A and B is $\frac{2}{3}$, find v

Your turn

Two particles A and B are travelling in the same direction on a smooth surface with speeds $4\ ms^{-1}$ and $3\ ms^{-1}$ respectively.
They collide directly, and immediately after the collision continue to travel in the same direction with speeds $2\ ms^{-1}$ and $v\ ms^{-1}$ respectively.
Given that the coefficient of restitution between A and B is $\frac{1}{3}$, find v

$v = 2.33$ (3 sf)

Worked example

Two particles A and B of masses 400g and 200g respectively are travelling in opposite directions towards each other on a smooth surface with speeds of $10ms^{-1}$ and $8ms^{-1}$ respectively.

They collide directly, and immediately after their collision have velocities $v_1\ ms^{-1}$ and $v_2\ ms^{-1}$ respectively, measured in the direction of the motion of A before the collision.

Given that the coefficient of restitution between A and B is $\frac{1}{4}$, find v_1 and v_2

Your turn

Two particles A and B of masses 200g and 400g respectively are travelling in opposite directions towards each other on a smooth surface with speeds of $5ms^{-1}$ and $4ms^{-1}$ respectively.

They collide directly, and immediately after their collision have velocities $v_1\ ms^{-1}$ and $v_2\ ms^{-1}$ respectively, measured in the direction of the motion of A before the collision.

Given that the coefficient of restitution between A and B is $\frac{1}{2}$, find v_1 and v_2

$v_1 = -4$ and $v_2 = 0.5$

Worked example

A particle A of mass m is moving with speed $4u$ on a smooth horizontal table.
The particle collides directly with a particle B of mass $2m$ moving with speed u in the same direction as A.
The coefficient of restitution between A and B is $\frac{1}{4}$.

a) Find the speed of B after the collision
b) Find the speed of A after the collision

Your turn

A particle A of mass $2m$ is moving with speed $2u$ on a smooth horizontal table.
The particle collides directly with a particle B of mass $4m$ moving with speed u in the same direction as A.
The coefficient of restitution between A and B is $\frac{1}{2}$.

a) Find the speed of B after the collision
b) Find the speed of A after the collision

a) $\frac{3u}{2}$
b) u

Worked example

A uniform sphere A of mass m is moving with speed u on a smooth horizontal table when it collides directly with another uniform sphere B of mass $4m$ which is at rest on the table. The spheres are of equal radius and the coefficient of restitution between them is e. The direction of motion of A is unchanged by the collision.

a) Find the speeds of A and B immediately after the collision

b) Find the range of possible values of e

Your turn

A uniform sphere A of mass m is moving with speed u on a smooth horizontal table when it collides directly with another uniform sphere B of mass $2m$ which is at rest on the table. The spheres are of equal radius and the coefficient of restitution between them is e. The direction of motion of A is unchanged by the collision.

a) Find the speeds of A and B immediately after the collision

b) Find the range of possible values of e

a) $v_A = \frac{u}{3}(1-2e)$; $v_B = \frac{u}{3}(1+e)$

b) $e < \frac{1}{2}$

Worked example

Two balls P and Q have massed $6m$ and $8m$ respectively. They are moving in opposite directions towards each other along the same straight line on a smooth level floor.
Immediately before they collide, P has speed $6u$ and Q has speed $4u$.
The coefficient of restitution between P and Q is e.
By modelling the balls as smooth spheres and the floor as a smooth horizontal plane,

a) Find the speed of Q after the collision
b) Given that the direction of motion of P is unchanged, find the range of possible values of e
c) Given that the magnitude of the impulse of P on Q is $\frac{320mu}{9}$, find the value of e

Your turn

Two balls P and Q have massed $3m$ and $4m$ respectively. They are moving in opposite directions towards each other along the same straight line on a smooth level floor.
Immediately before they collide, P has speed $3u$ and Q has speed $2u$.
The coefficient of restitution between P and Q is e.
By modelling the balls as smooth spheres and the floor as a smooth horizontal plane,

a) Find the speed of Q after the collision
b) Given that the direction of motion of P is unchanged, find the range of possible values of e
c) Given that the magnitude of the impulse of P on Q is $\frac{80mu}{9}$, find the value of e

a) $\frac{u}{7}(15e + 1)$

b) $0 \leq e < \frac{1}{20}$

c) $e = \frac{1}{27}$