Key words

momentum
Newton's laws of motion
vector
velocity

Momentum

- *Momentum*, a *vector* quantity is the product of an object's mass and *velocity*.
- It is measured in kilogram meters per second, $kgms^{-1}$ or Newton seconds.
- Following *Newton's laws of motion*, a system's total momentum is constant unless a net external force acts. This applies in cases of impact and disintegration.

1 Transferred momentum

- The momentum of pendulum A is transferred to pendulum B.

2 Collision of two cars

- If the cars were traveling with equal momentum in opposite directions before impact they would remain at the point of impact as the net momentum would be zero.
- If one car had more momentum than the other the cars would continue to move after impact.

3 Rocket propulsion

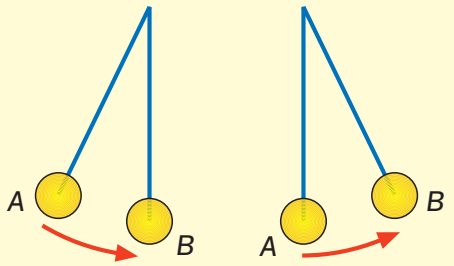
- The momentum of the rocket moving in one direction is equal to the momentum of the exhaust gases moving in the opposite direction.

4 Conservation of momentum

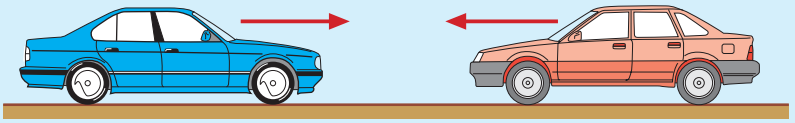
- In momentum calculations, movement to the right is considered positive, movement to the left negative.
- When the spring is released the trolleys move apart as shown.
- Since momentum is conserved momentum of trolley A + momentum of trolley B = 0.
- Mass of trolley A = 2m; velocity = $- v_A$. Its momentum = $- 2m \times v_A$. Mass of trolley B = m; velocity v_B. Its momentum = mv_B.
  As momentum is conserved,
  $- 2mv_A + mv_B = 0$; $2mv_A = mv_B$
  Trolley A's velocity is half trolley B's.

Momentum

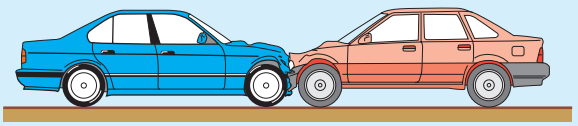
1 Transferred momentum



2 Collision of two cars

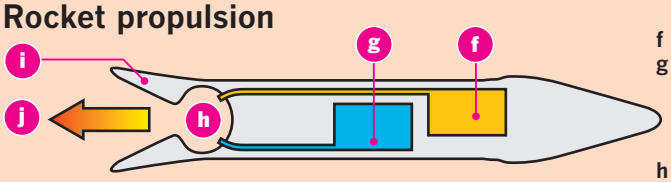


Before:
momentum to left + momentum to right = zero



After:
total momentum is zero

3 Rocket propulsion

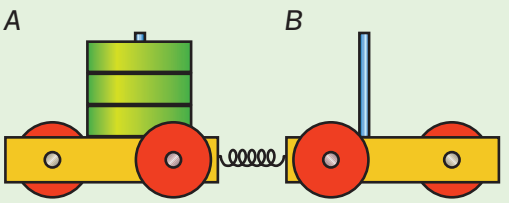


f liquid hydrogen
g liquid oxygen

h combustion chamber
i nozzle
j hot gasses

Rate of change of rocket momentum + rate of change of momentum of ejected hot gases

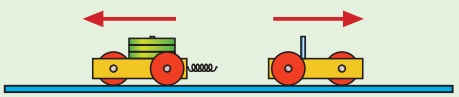
4 Conservation of momentum



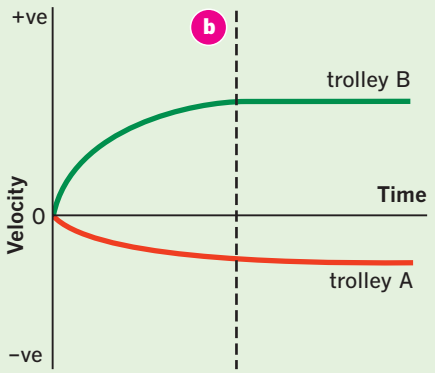
Two mechanics trolleys that can be pushed apart by a compressed spring: mass of trolley *A* = 2 × mass of trolley *B*

a trolley runway
b point where trolleys physically separate

Spring is released by hitting with a hammer



Trolleys move apart



Velocity-time graph