


# Kinetic Energy

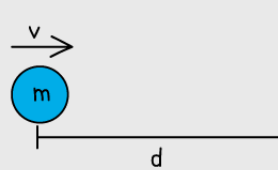
## Derivation of $KE = \frac{1}{2}mv^2$

- Kinetic energy is energy an object has due to its **motion** (or velocity)
- A force can make an object accelerate; work is done by the force and energy is transferred to the object
- Using this concept of work done and an equation of motion, the extra work done due to an object's speed can be derived
- The derivation for this equation is shown below:



Derivation of  $KE = \frac{1}{2}mv^2$

CONSIDER A MASS  $m$  AT REST WHICH ACCELERATES TO A SPEED  $v$  OVER A DISTANCE  $d$



The diagram shows a blue circle labeled 'm' representing a mass. Above it is a horizontal arrow pointing to the right, labeled 'v' for velocity. Below the mass is a horizontal line with vertical end caps, labeled 'd' for distance.

WORK DONE IN ACCELERATING THE MASS

$W = F \times d$

AND  $F = ma$  FROM NEWTON'S SECOND LAW

RECALL THE SUVAT EQUATION

$$v^2 = u^2 + 2as$$

IF  $u = 0$  AND  $s = d$

$$v^2 = 2ad$$

REARRANGING FOR  $a$

$$a = \frac{v^2}{2d}$$

SUBSTITUTE BACK INTO  $F = ma$

$$F = ma = \frac{mv^2}{2d}$$

SUBSTITUTE THIS FORCE  $F$  INTO THE WORK DONE EQUATION

$$W = \frac{mv^2}{2d} \times d = \frac{1}{2}mv^2$$

THE MASS IS NOW ABLE TO DO EXTRA WORK  $= \frac{1}{2}mv^2$   
DUE TO ITS SPEED

IT HAS KINETIC ENERGY  $= \frac{1}{2}mv^2$

## Kinetic Energy

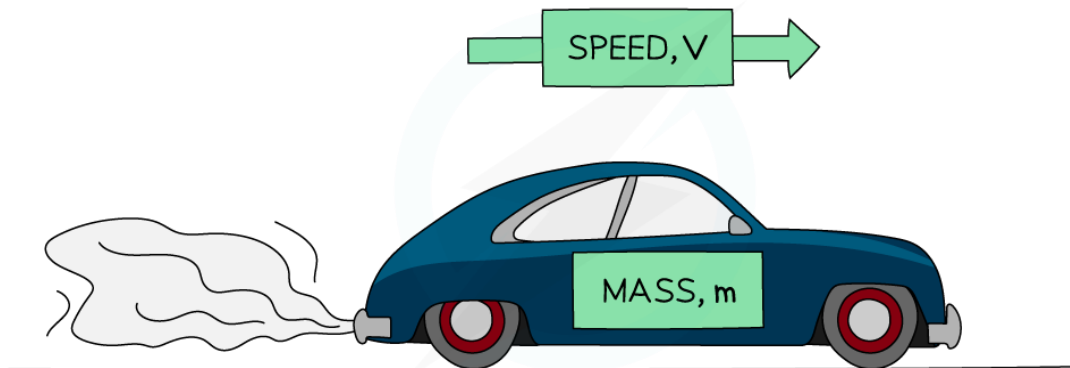
- Kinetic energy is energy an object has due to its **motion** (or velocity)
  - The faster an object is moving, the greater its kinetic energy
- When an object is falling, it is **gaining** kinetic energy since it is gaining speed. This energy transferred from the gravitational potential energy it is losing
- An object will maintain this kinetic energy unless its speed changes

$$KE = \frac{1}{2}mv^2$$

KINETIC ENERGY (J)

MASS (kg)

VELOCITY (ms<sup>-1</sup>)



***KE: The energy an object has when its moving***

## Worked example



A body travelling with a speed of  $12 \text{ ms}^{-1}$  has kinetic energy  $1650 \text{ J}$ .

If the speed of the body is increased to  $45 \text{ ms}^{-1}$ , what is its new kinetic energy?



STEP 1

EQUATION FOR KINETIC ENERGY

$$\text{KE} = \frac{1}{2}mv^2$$

STEP 2

MASS WILL NOT CHANGE, SO CAN BE CALCULATED FROM ITS INITIAL KINETIC ENERGY

REARRANGE FOR MASS  $m$

$$m = \frac{2 \times \text{KE}}{v^2} = \frac{2 \times 1650}{12^2} = 23 \text{ kg}$$

STEP 3

SUBSTITUTE INTO KINETIC ENERGY EQUATION

USING VALUE OF MASS AND NEW VALUE OF VELOCITY

$$\text{KE} = \frac{1}{2} \times 23 \times 45^2 = 23000 \text{ J (2 s.f)}$$