Kinetic Energy

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Kinetic Energy: the energy of motion

KE or E_K

Units → J

scalar → cannot be negative

① Moving → Has KE (positive)

② Not Moving → No KE = 0

Derivation for KE

① Motion → kinematics

$v_f^2 = v_i^2 + 2ad$

$v_f^2 = 2ad$

$v_f^2 = 2\frac{F}{m}d$

$\frac{1}{2}m\, v_f^2 = \frac{2\, KE_f}{\frac{1}{2}\, m}$

② $v_i = 0$

$KE = 0$

$v_i = 0$

③ $W = \Delta E$

If I bring an object from rest to some speed

$W = KE_f - KE_i$

$W = KE_f - 0$

$W = KE_f$

How to connect W to v?

$W = F \cdot d$

$F = m \cdot a$

$a = \frac{F}{m}$

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

What is the kinetic energy of a 3kg box that is thrown at 4m/s?

$KE = \frac{1}{2}mv^2 = \frac{1}{2}(3)(4)^2 = \frac{1}{2}(3)(16) = 24\text{ J}$

Work-Energy Theorem

- If a net force is acting on an object, the object will accelerate.
- Acceleration is the rate of change of velocity.
- Therefore the force must be proportional to the change in Kinetic Energy.

Therefore → ∴ $\Delta KE = F \cdot d$

A sprinter exerts a net force of 260N over 35m. What is the sprinter's change in kinetic energy?

$$\Delta KE = F \cdot d$$
$$= 260 \times 35 = \boxed{9100\,J}$$

A student accelerates a box, initially at rest, using a 160N force over 12m. If the box has a mass of 10kg, what is the final velocity of the box?

$$\Delta KE = F \cdot d$$
$$KE_f - KE_i = F \cdot d$$
$$KE_f = F \cdot d$$
$$\frac{1}{2}mv^2 = F \cdot d$$
$$\sqrt{v^2} = \sqrt{\frac{2Fd}{m}}$$

→ $$V = \sqrt{\frac{2Fd}{m}}$$
$$V = \sqrt{\frac{2(160)(12)}{10}}$$
$$\boxed{V = 19.6\,m/s}$$

Proportionality

you are driving a golf cart
What happens to the kinetic energy if:

proportional to

$KE \propto m$

a) Double the mass $v = constant$

$K = \frac{1}{2} m v^2$ $KE = \frac{1}{2}(2m)v^2$ $2(\frac{1}{2}mv^2)$

Doubles the kinetic energy

b) half the mass? $v = constant$

Halve the kinetic energy

$KE \propto v^2$

c) $m = constant$ $v = doubled$

$KE = \frac{1}{2}mv^2 \Rightarrow KE = \frac{1}{2}m(2v)^2 \Rightarrow 4(\frac{1}{2}mv^2)$

Four times the energy

d) $m = constant$ $v = half$

$(\frac{1}{2})^2 = \frac{1}{4}$ the energy