SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution

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DEPARTMENT OF AUTOMOBILE ENGINEERING

19AUE302 – AUTOMOTIVE SAFETY & INFOTRONICS

III YEAR / V SEM

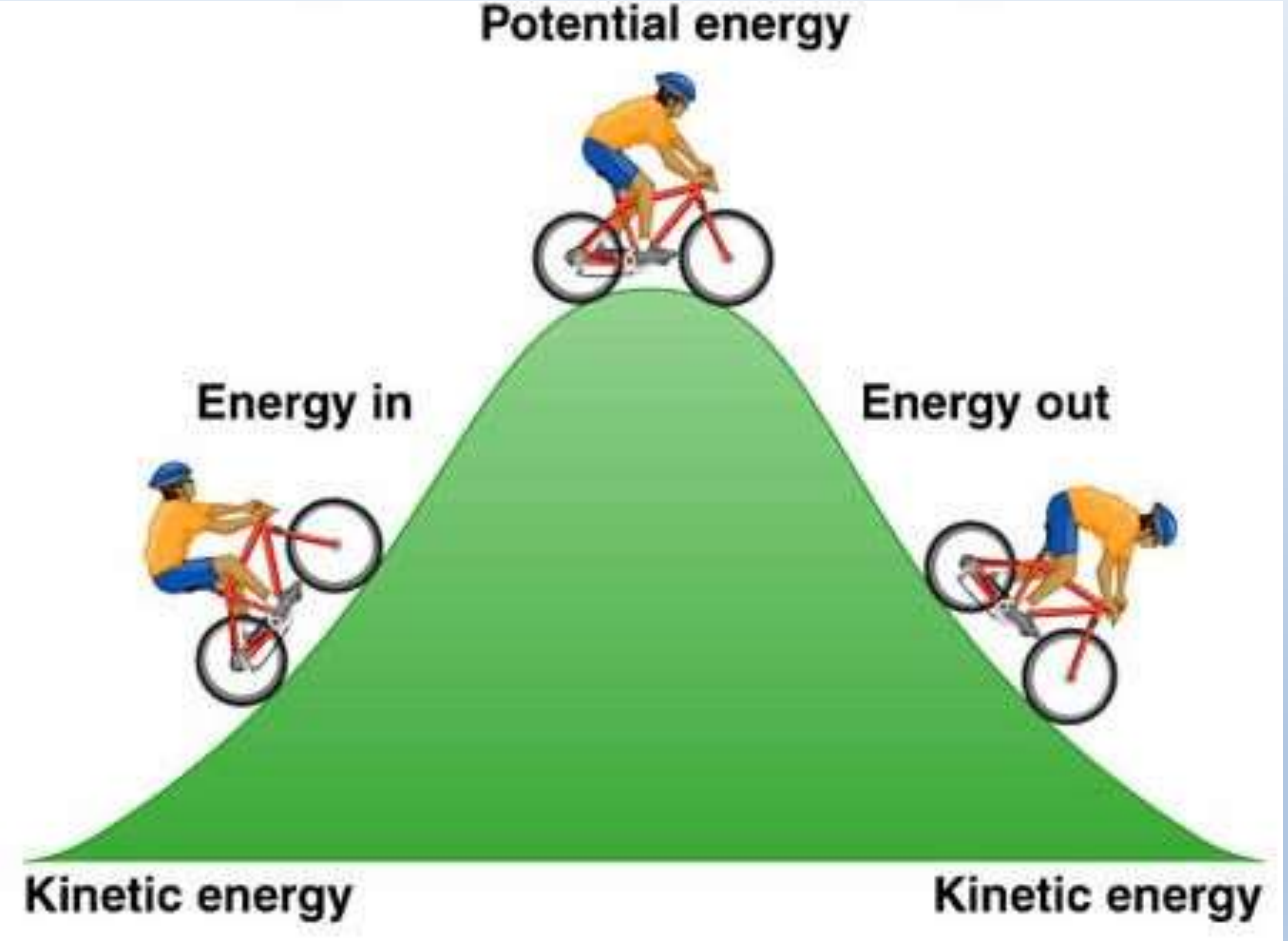
UNIT – 1 INTRODUCTION

Topic – 2 Energy Equation

PRESENTATION OUTLINE

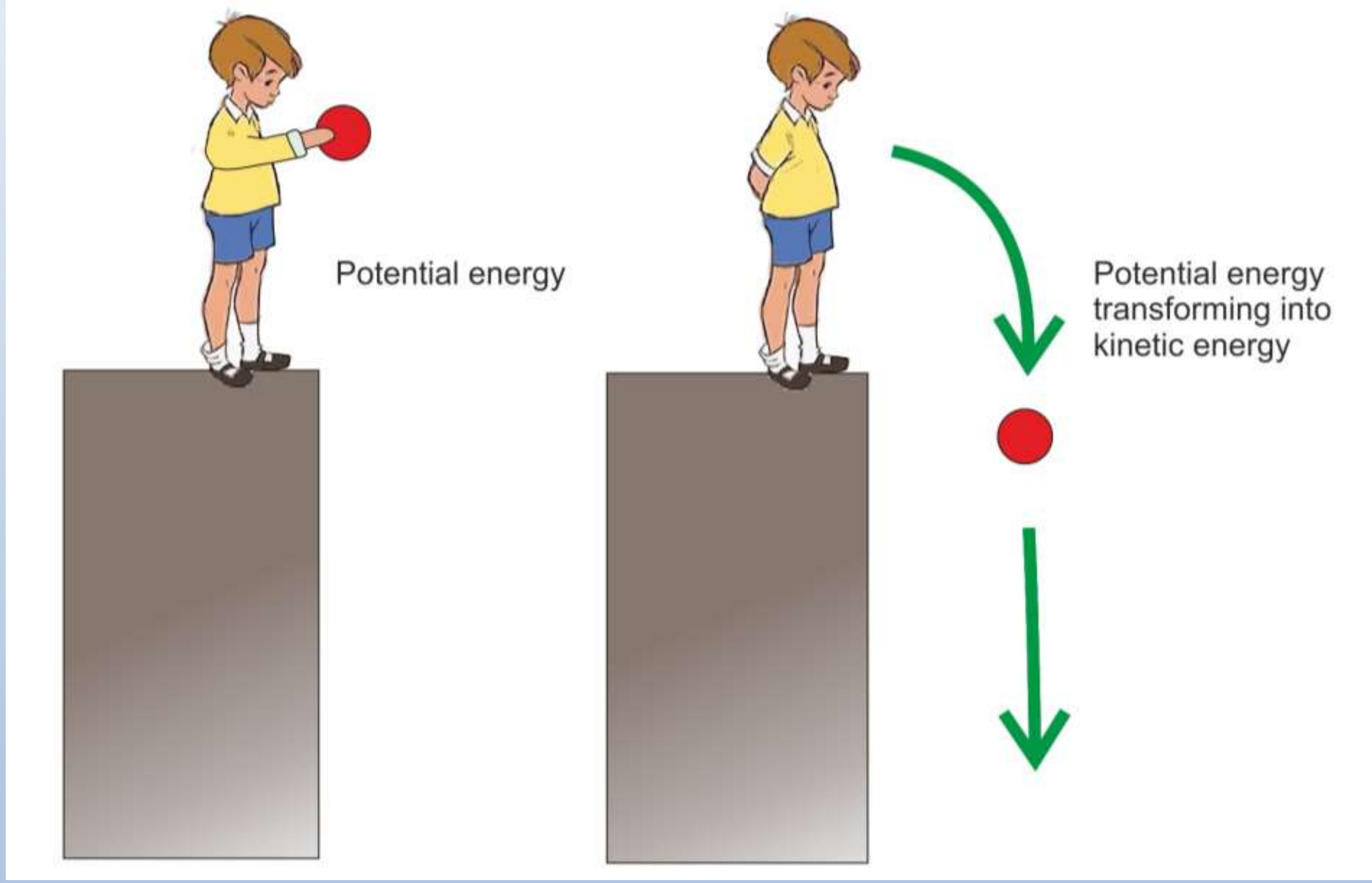
- Potential Energy
- Kinetic Energy
- Impact of Kinetic Energy

POTENTIAL ENERGY



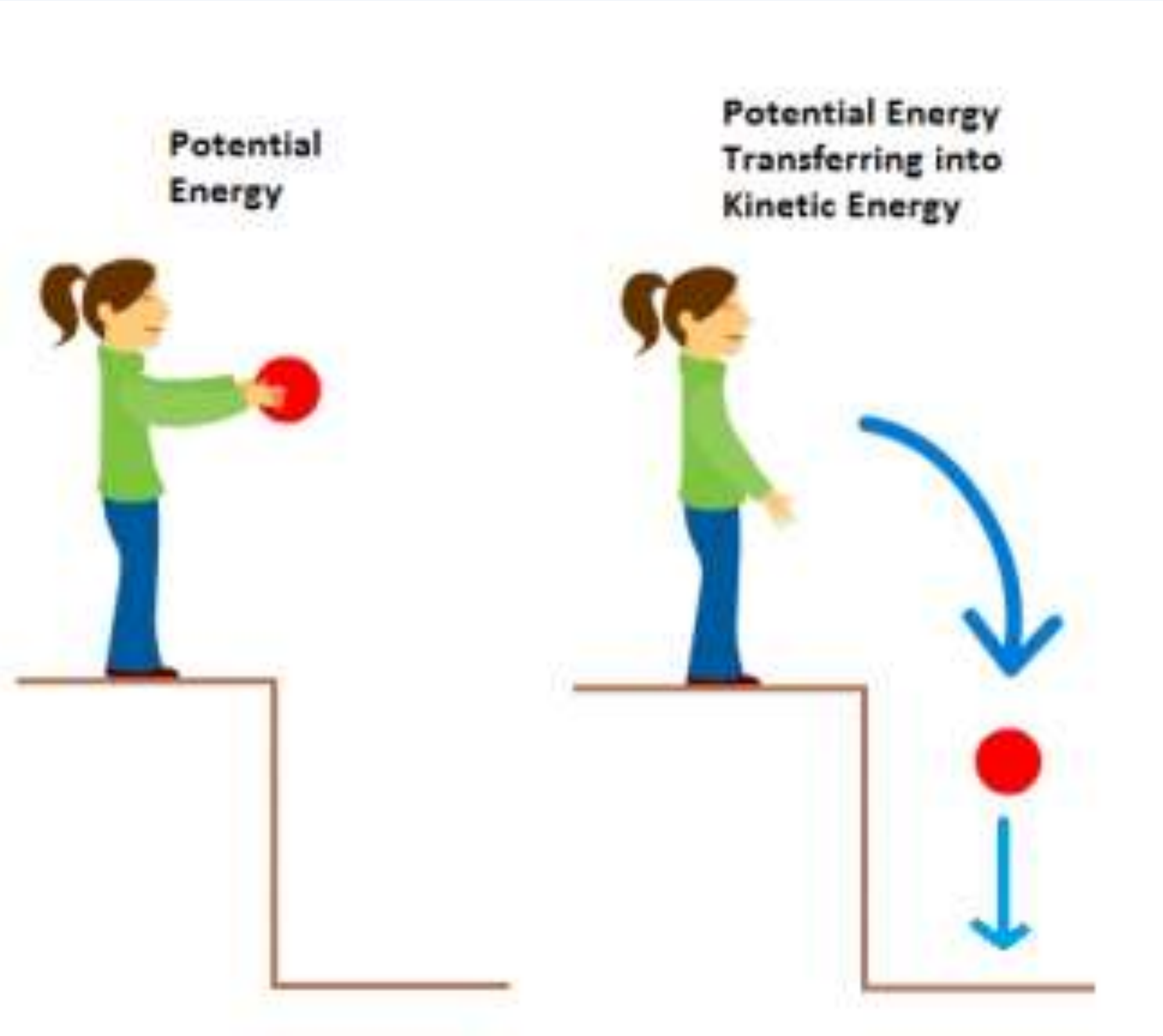
- Potential energy is energy that is stored – or conserved - in an object or substance
- This stored energy is based on the position, arrangement or state of the object or substance
- You can think of it as energy that has the 'potential' to do work

KINETIC ENERGY



- The kinetic energy (KE) of an object is the energy that it possesses due to its motion
- It is defined as the work needed to accelerate a body of a given mass from rest to its stated velocity
- Having gained this energy during its acceleration, the body maintains this kinetic energy unless its speed changes

KINETIC ENERGY

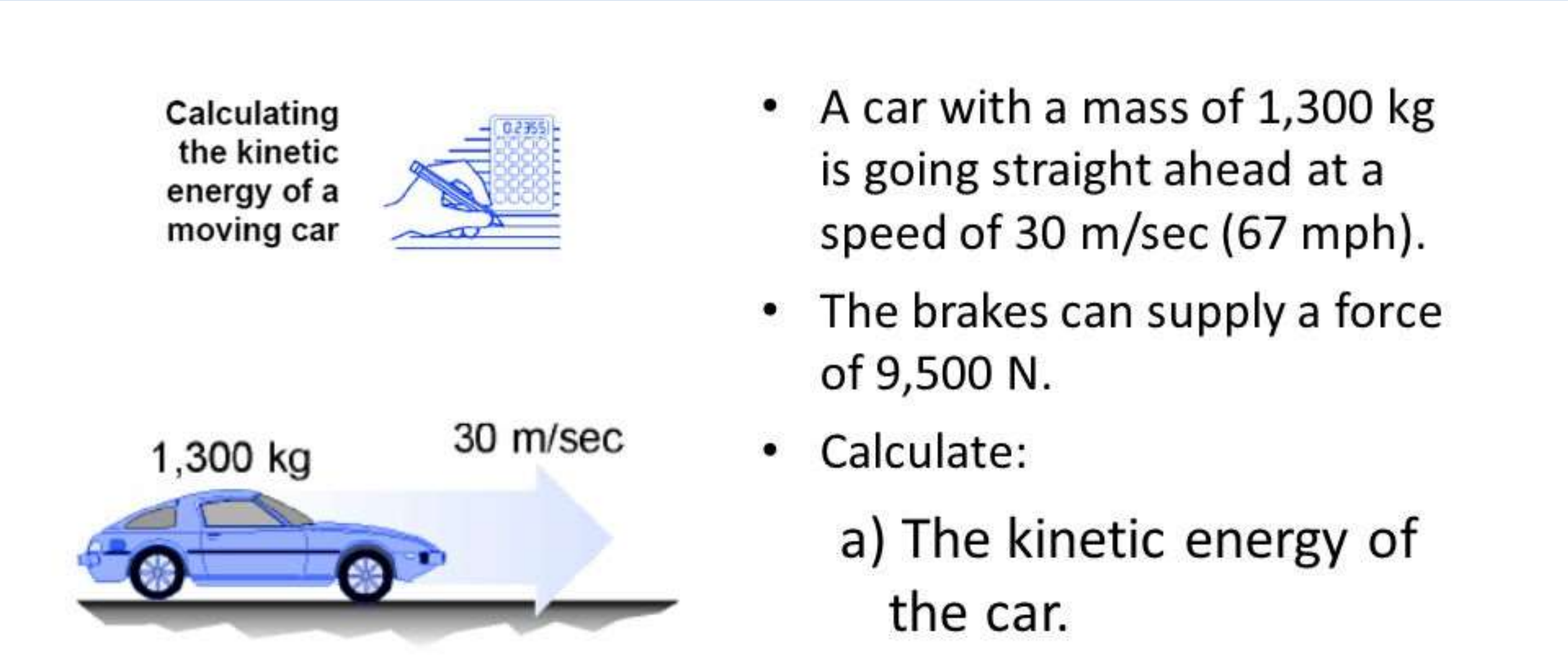


- Kinetic energy is energy of motion
- Objects that are moving, such as a roller coaster, have kinetic energy (KE) If a car crashes into a wall at 5 mph, it shouldn't do much damage to the car
- But if it hits the wall at 40 mph, the car will most likely be totaled
- Kinetic energy is similar to potential energy
- The more the object weighs, and the faster it is moving, the more kinetic energy it has
- The formula for KE is: KE = 1/2*m*v2 where m is the mass and v is the velocity

EFFECT OF KINETIC ENERGY

- Kinetic energy is that it increases with the velocity squared
- This means that if a car is going twice as fast, it has four times the energy
- You may have noticed that your car accelerates much faster from 0 mph to 20 mph than it does from 40 mph to 60 mph
- Let's compare how much kinetic energy is required at each of these speeds
- At first glance, you might say that in each case, the car is increasing its speed by 20 mph, and so the energy required for each increase must be the same. But this is not so

EFFECT OF KINETIC ENERGY



- We can calculate the kinetic energy required to go from 0 mph to 20 mph by calculating the KE at 20 mph and then subtracting the KE at 0 mph from that number
- In this case, it would be $1/2*m*20^2 - 1/2*m*0^2$. Because the second part of the equation is 0, the KE = $1/2*m*20^2$, or 200 m.

- For the car going from 40 mph to 60 mph, the KE = $1/2*m*60^2 - 1/2*m*40^2$; so KE = 1,800 m - 800 m, or 1000 m. Comparing the two results, we can see that it takes a KE of 1,000 m to go from 40 mph to 60 mph, whereas it only takes 200 m to go from 0 mph to 20 mph

Energy Equation

- Conservation of energy principle provides a powerful tool for problem solving.
- Newton's laws for many standard problems.
- There are methods using energy which are more straightforward.

- For example, the solution for the impact velocity of a falling object is much easier by energy methods. The basic reason for the advantage of the energy approach is that just the beginning and ending energies need be considered; intermediate processes do not need to be examined in detail since conservation of energy guarantees that the final energy of the system is the same as the initial energy.

Energy Equation (Contd.,)

Let us consider Vehicles 1, 2 are involved in a crash. Then,

M_1, M_2	Masses of Vehicle 1,2 respectively.
V_1, V_2	Impact Velocities of vehicles 1,2 respectively.
V_1', V_2'	Post Impact velocities of vehicles 1,2 respectively.
V_{cl}	Closing Speed $(V_1 - V_2)$ immediately prior to impact.
e_c	Coefficient of restitution for the car to car impact.
e_b	Coefficient of restitution for car to barrier impact.
d_1, d_2	Crush of vehicle 1,2 respectively.
k_1, k_2	Frontal stiffness of 1,2 respectively.
E_c	Total system crush energy for car to car collision.
E_{c_1}, E_{c_2}	Crush energy of vehicle 1,2 respectively.

Energy Equation (Contd.,)

The conservation of linear momentum for a two vehicle collision is:

$$M_1V_1 + M_2V_2 = M_1V_1' + M_2V_2' \quad (1)$$

WHERE:

M = MASS

V = IMPACT VELOCITY

V' = POST-IMPACT VELOCITY

1,2 = SUBSCRIPTS REFER TO VEHICLE 1.2

Energy Equation (Contd.,)

$$V_1' = \frac{M_1V_1 + M_2V_2 - M_2V_2'}{M_1} \qquad \textbf{(2)}$$

The coefficient of Restitution may be defined as follows:

$$e = \frac{V_2' - V_1'}{V_1 - V_2} \qquad (3)$$

Where e = coefficient of restitution

Combining (2) and (3) yields:

$$\Delta V_1 = \frac{M_2}{M_1 + M_2}(1+e)(V_1 - V_2) \qquad (4)$$

Energy Consideration

The total crush energy in a collision is equal to the difference between Kinetic Energy going to the collision and the Kinetic Energy going out of the collision.

$$E_c = \frac{1}{2}(M_1V_1^2 + M_2V_2^2 - M_1V_1'^2 - M_2V_2'^2) \quad (5)$$

Combining Momentum and Energy Consideration

Plugging in the known post impact velocities from eqn (2) into egn (5) and simplifying the results in an eqn for total system crush energy in terms of the closing speed between the two vehicles, Eqn (6) will be,

$$E_c = \frac{1}{2}\frac{M_1 M_2}{M_1 + M_2}(V_1 - V_2)^2(1 - e_c^2) \quad (6)$$

Combining Momentum and Energy Consideration

Crush Energy absorbed by the vehicle,

i.e., This equals to the ratio of the vehicles crush to the total system crush

$$E_{c_1} = \frac{d_1}{d_1 + d_2}(E_c) \qquad (7)$$

Combining Momentum and Energy Consideration

Kinetic Energy (KE) in crush for a rigid barrier impact is expressed as

$$K.E. = \frac{1}{2} M_1 (BEV)^2 (1 - e_B^2) \quad (8)$$

Eqn (7) = (8) - Simplify

$$BEV_1 = (V_1 - V_2) \sqrt{\left(\frac{d_1}{d_1 + d_2}\right)\left(\frac{M_2}{M_1 + M_2}\right)\left(\frac{1 - e_c^2}{1 - e_b^2}\right)} \quad (9)$$

$$F_1 = F_2$$
$$k_1 d_1 = k_2 d_2 \quad (10)$$

Combining Momentum and Energy Consideration

This results in the final equation (11) shown below:

$$\Delta V_1 = BEV_1(1+e_c)\sqrt{\left(\frac{k_1+k_2}{k_2}\right)\left(\frac{M_2}{M_1+M_2}\right)\left(\frac{1-e_b^2}{1-e_c^2}\right)} \quad (11)$$