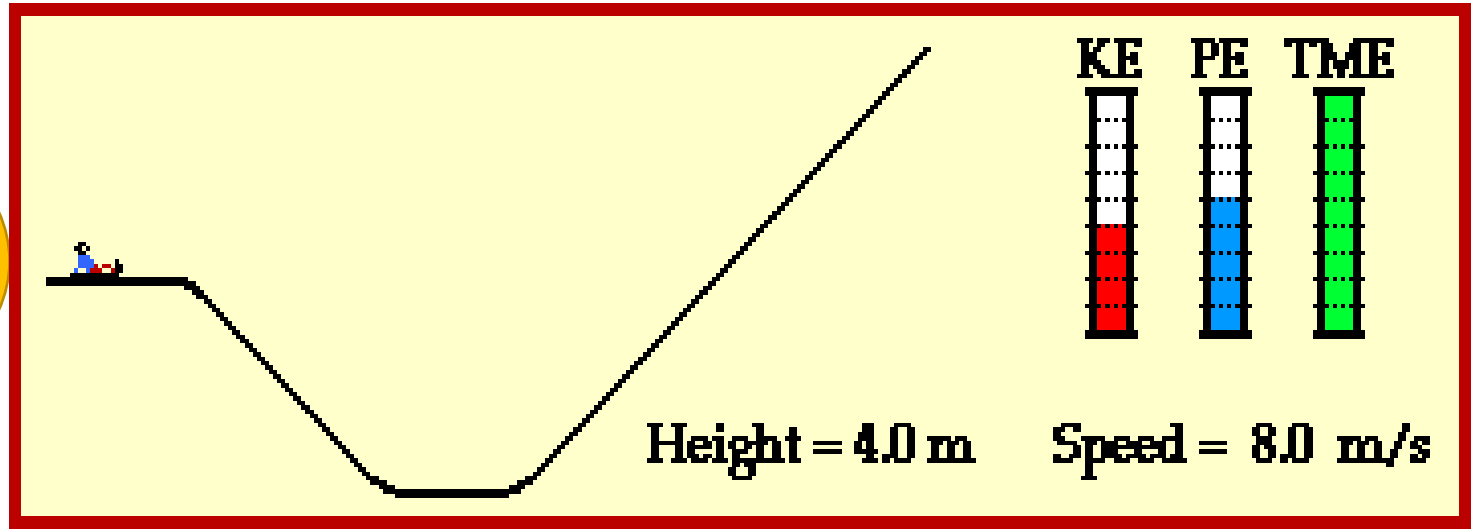
Work Power & Energy

- By Saurabh sir

Physics By Saurabh Sir

WELCOME TO THE
NDA PHYSICS CLASSES
BY SAURABH SIR



TODAYS WE WILL TALK ABOUT METHODS OF WORK AND ENERGY

Work of a Force

एक फोर्स का काम

work is the product of force and displacement.

कार्य बल और विस्थापन का उत्पाद है।

Work transfers energy from one place to another, or one form to another.

The SI unit of work is the joule (J).

काम ऊर्जा को एक स्थान से दूसरे स्थान पर, या एक रूप से दूसरे में स्थानांतरित करता है।

- *कार्य की SI इकाई जूल (J) है।*

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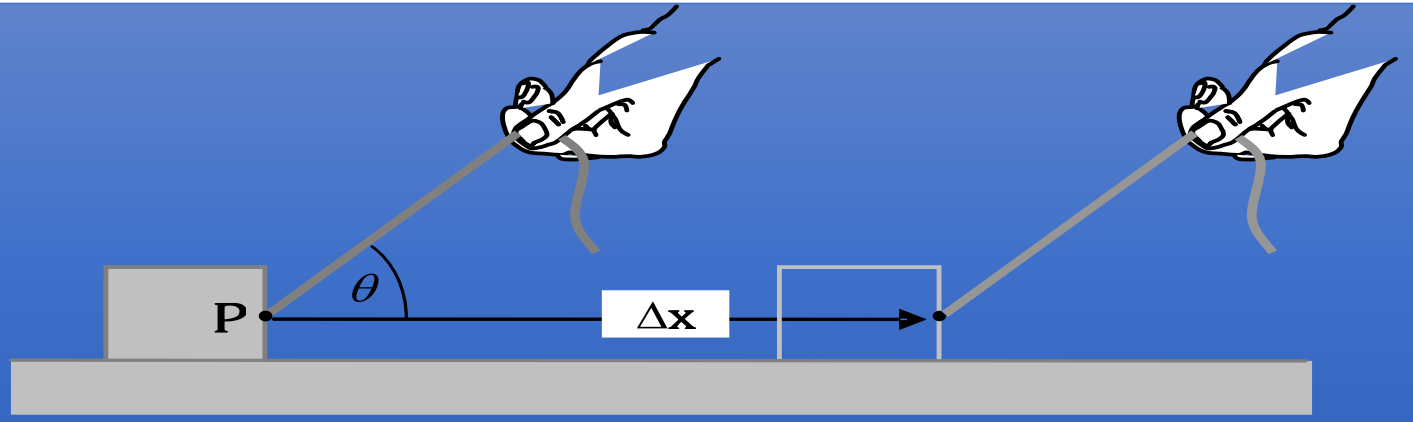
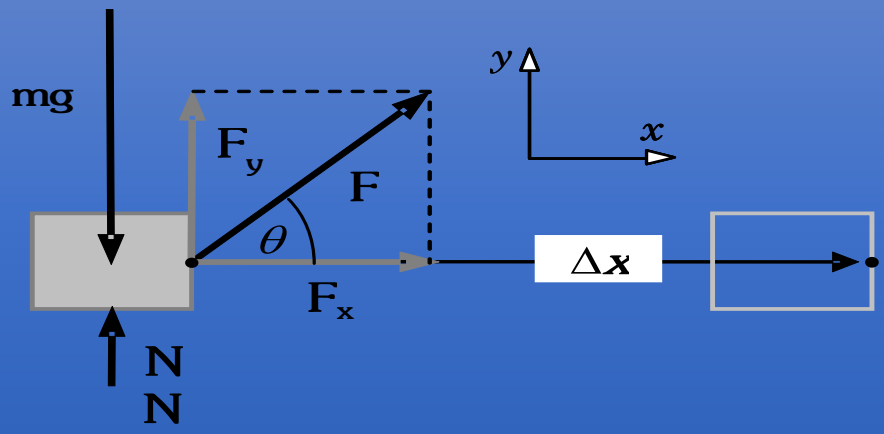




$$W \propto F_x \cdot \Delta x = F\cos\theta \cdot \Delta x$$

$$W = F\cos\theta \cdot \Delta x = \vec{F} \cdot \Delta\vec{x}$$

SI unit	N.m	Joule
CGS unit	dyne-cm	Erg
Dimensional formula	ML^2T^{-2}	

$$1\,Joule = 1\,Newton \times 1m$$

$$1\,Newton = 1kg \times 1ms^{-2} = 10^3 \times 10^2 = 10^5\,g\,cms^{-2}$$

$$1m = 100\,cm = 10^2\,cm$$

$$\Rightarrow 1\,Joule = 10^5 \times 10^2 = 10^7\,erg$$

Nature Of work done:-

1. *Positive Work : If a force displaces the object in its direction, then the work done is positive.*
2. *Zero Work : If the directions of force and the displacement are perpendicular to each other, the work done by the force on the object is zero.*
3. *Positive Work : If a direction of force is just opposite to the direction of displacement, the work done by the force on the object is negative.*

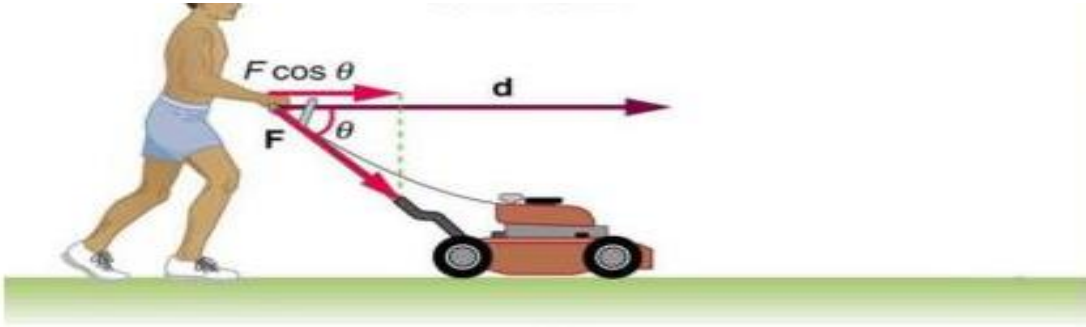
(a) The work done by the force **F** on this lawn mower is $Fd\cos\theta$. Note that $F\cos\theta$ is the component of the force in the direction of motion.

(b) A person holding a briefcase does no work on it, because there is no motion. No energy is transferred to or from the briefcase.

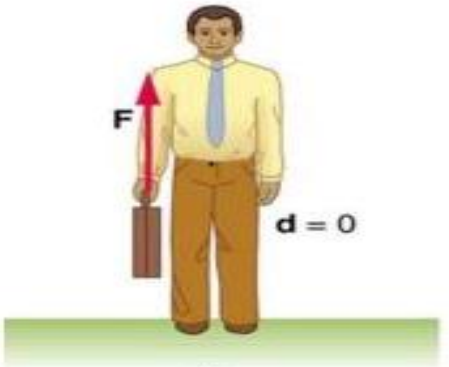
(c) The person moving the briefcase horizontally at a constant speed does no work on it, and transfers no energy to it.

(d) Work *is* done on the briefcase by carrying it up stairs at constant speed, because there is necessarily a component of force **F** in the direction of the motion. Energy is transferred to the briefcase and could in turn be used to do work.

(e) When the briefcase is lowered, energy is transferred out of the briefcase and into an electric generator. Here the work done on the briefcase by the generator is negative, removing energy from the briefcase, because **F** and **d** are in opposite directions.



(a)



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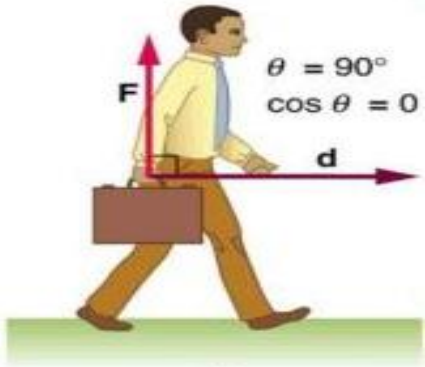
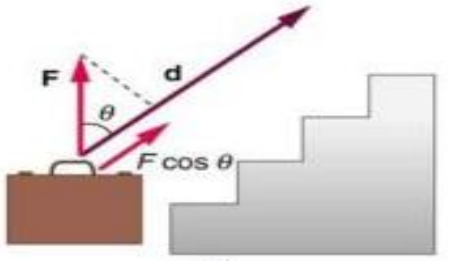
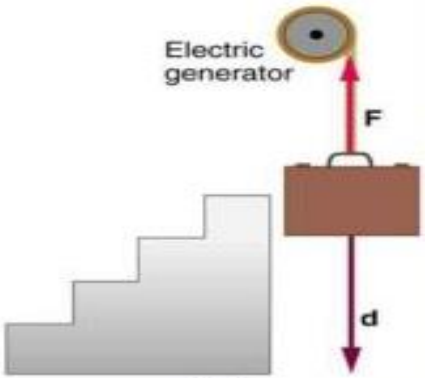


(c)



(d)



(e)

Conservative Forces:-

A conservative force is a force with the property that the total work done in moving a particle between two points is independent of the taken path.

एक रूढ़िवादी बल संपत्ति के साथ एक बल है जो दो बिंदुओं के बीच एक कण को स्थानांतरित करने में किए गए कुल काम से स्वतंत्र है।

Conservative Forces

Conservative Forces Vs Nonconservative Forces

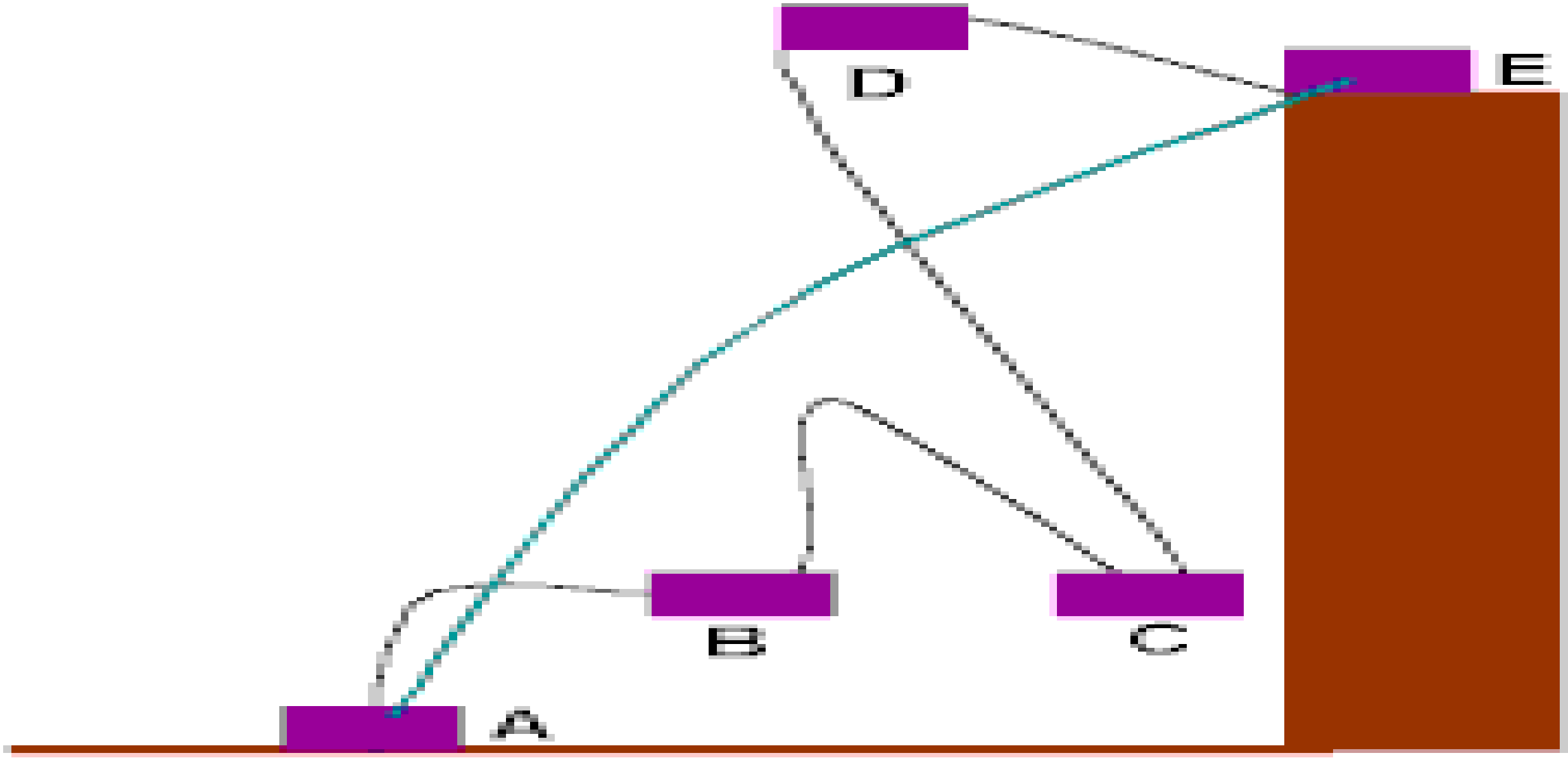
Electric Force
Gravitational Force
Elastic Force

Friction
Applied Force
Push & Pull Action
Tension Force

$W_{NC} = \Delta ME$

$W_{net} = \Delta KE$

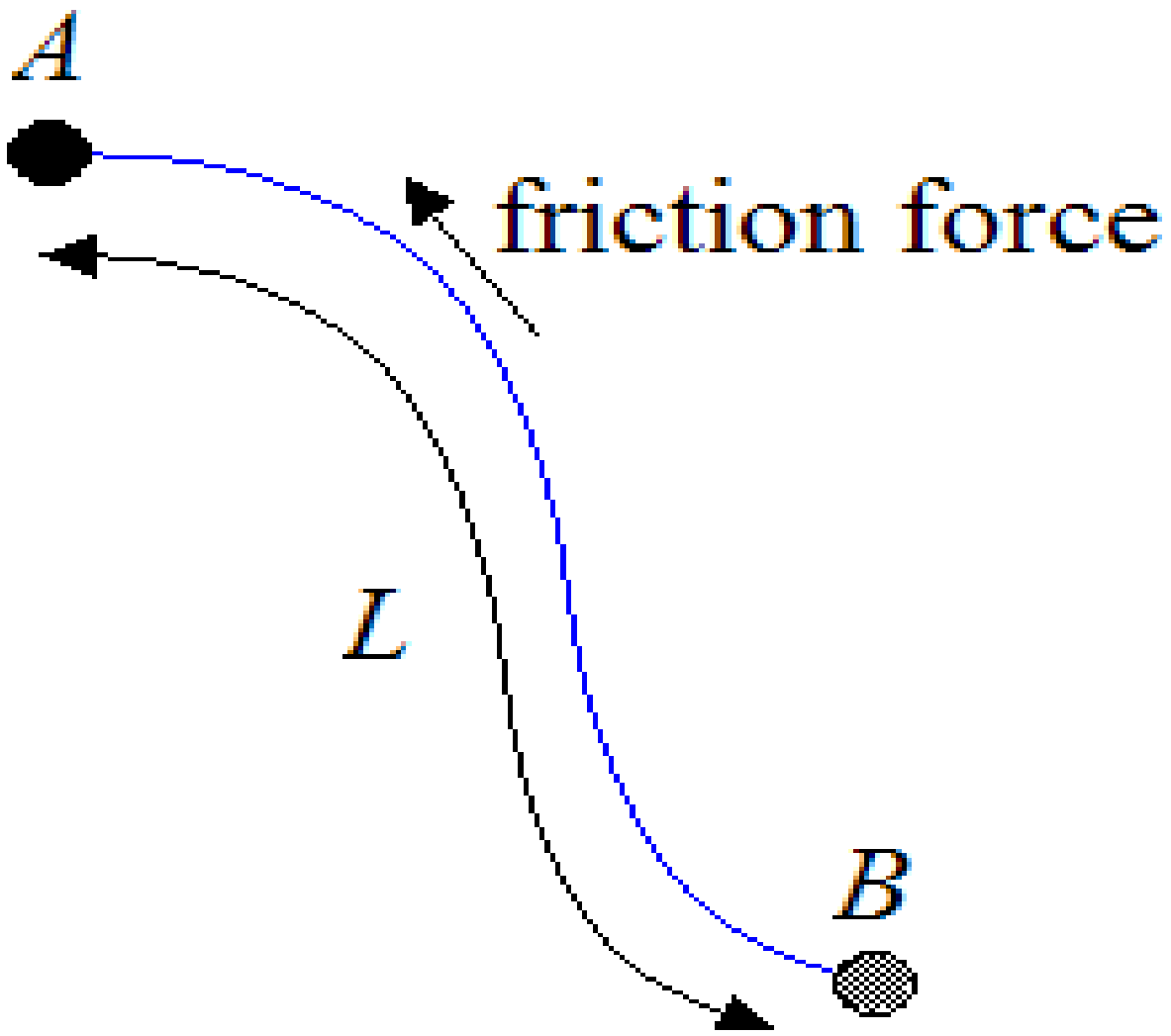
$W_G = -\Delta PE$


D
E
B
C
A

Non-Conservative force

A non-conservative force is one for which work depends on the path taken. Friction is a good example of a non conservative force.

एक गैर-रूढ़िवादी बल वह है जिसके लिए काम किए गए रास्ते पर निर्भर करता है। घर्षण एक गैर रूढ़िवादी बल का एक अच्छा उदाहरण है।


A
friction force
L
B

Energy

In physics, energy is the quantitative property that must be transferred to an object in order to perform work on, or to heat, the object. Energy is a conserved quantity; the law of conservation of energy states that energy can be converted in form, but not created or destroyed.

भौतिक विज्ञान में, ऊर्जा एक मात्रात्मक संपत्ति है जिसे किसी वस्तु को काम करने, या गर्म करने के लिए वस्तु को हस्तांतरित किया जाना चाहिए। ऊर्जा एक संरक्षित मात्रा है; ऊर्जा के संरक्षण का नियम कहता है कि ऊर्जा को रूप में परिवर्तित किया जा सकता है, लेकिन बनाया या नष्ट नहीं किया जा सकता है।

Different forms of Energy

Stored energy

Potential energy → Gravitational P.E (Height + mass)

Potential energy → Elastic P.E (Stretch, compress, bend)

$E_p = mgh$

A stretched rubber band

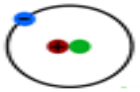
A compressed sp

$E_p = \frac{1}{2} kx^2$

Chemical energy (Food, fuel)

Food

Nuclear energy (Atoms)

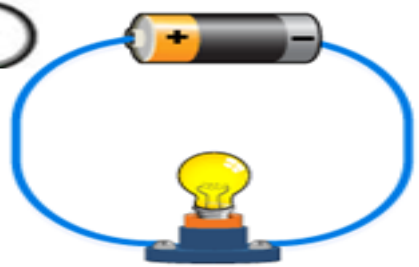


Working energy

Kinetic energy (Movement)

Heat energy (Heat)

Light energy (Light)

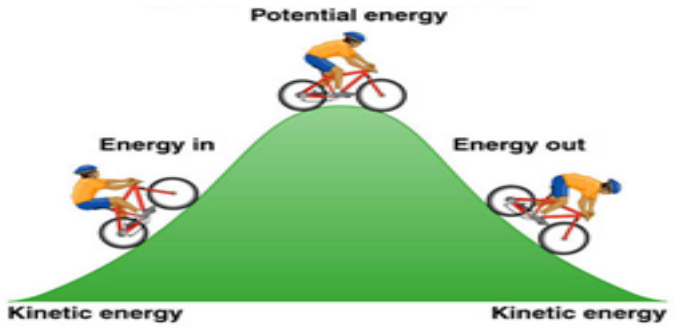


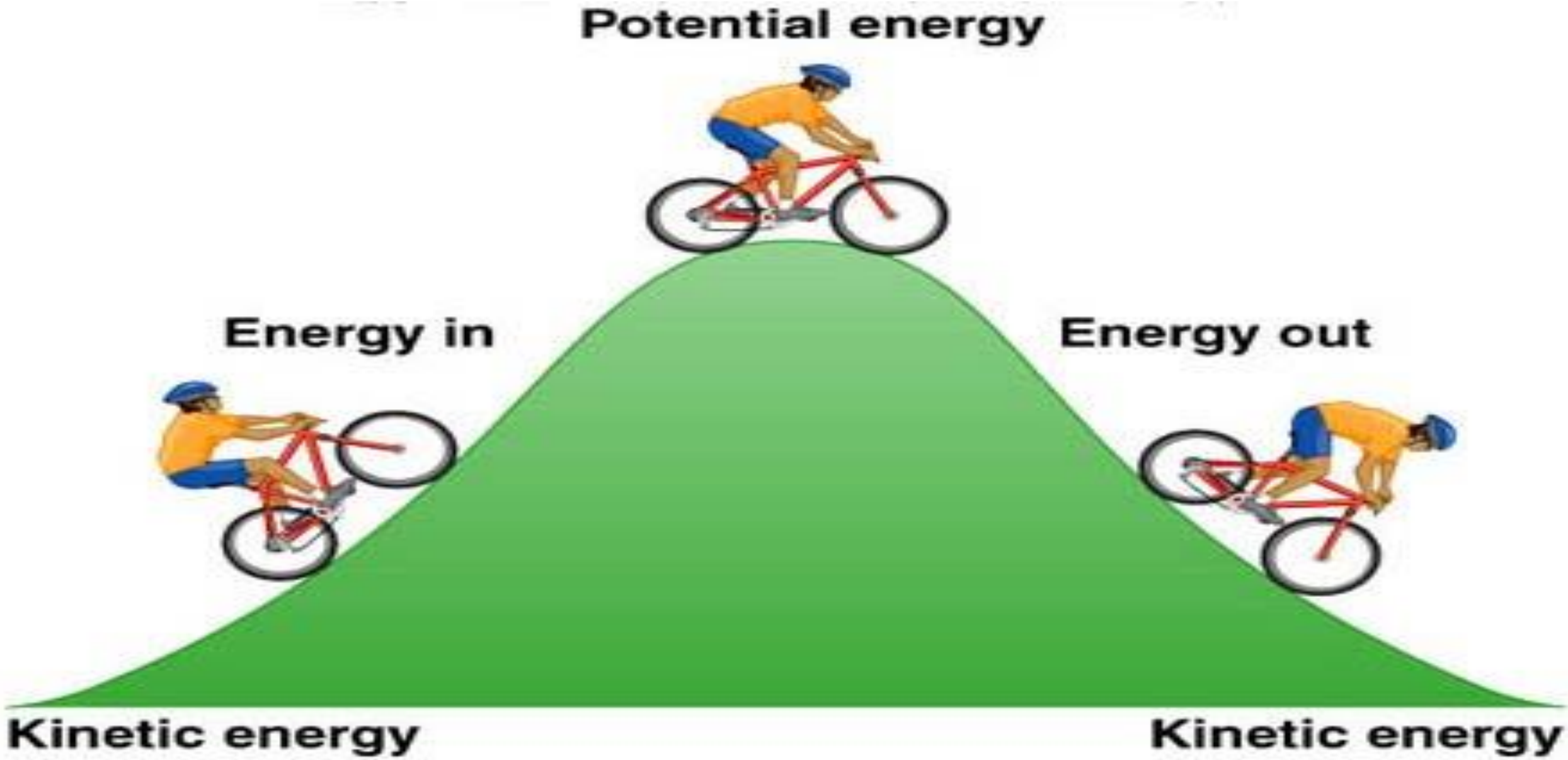
Electrical energy (Electricity)

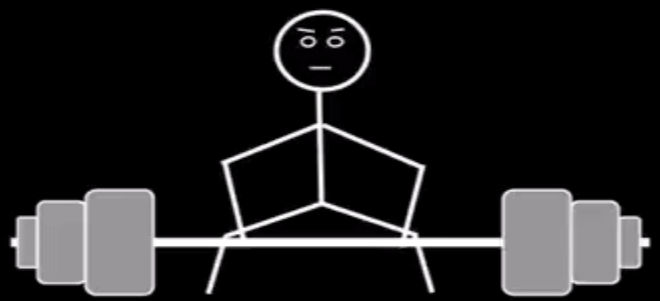
Sound energy (Vibrations)

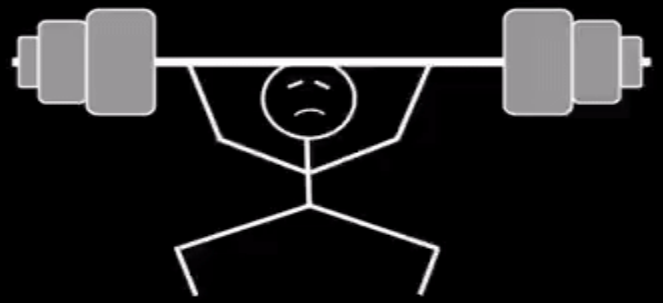
$E_k = \frac{1}{2} mv^2$

M.E = P.E + K.E



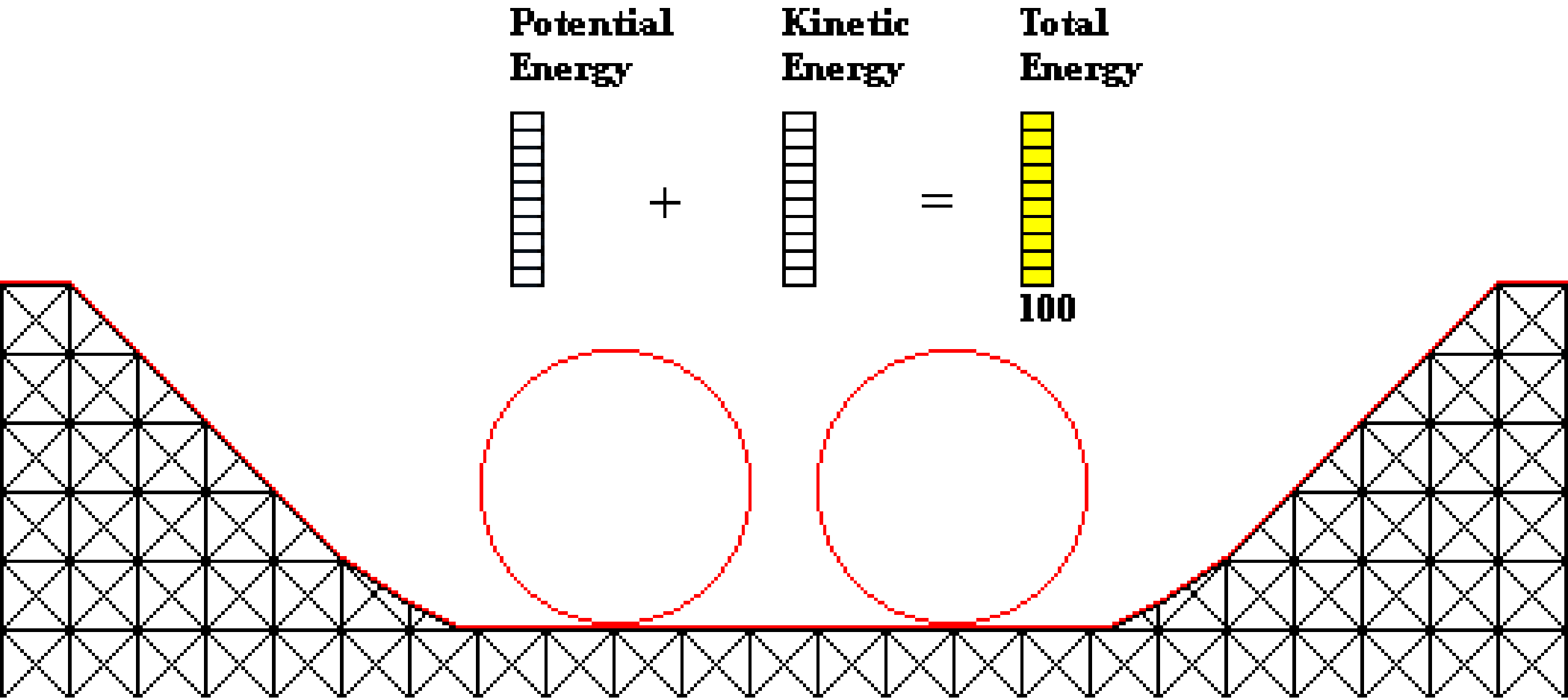

Potential energy
Energy in
Energy out
Kinetic energy
Kinetic energy





Work done by the body is the energy of the body.

And energy can neither be created nor be destroyed but it can be transferred from one form to another.


Potential Energy
Kinetic Energy
Total Energy
+
=
100

Power is the rate at which work is done or energy converted.

The scientific unit of power is the watt (W), which is equal to one joule per second.

पावर वह दर है जिस पर काम किया जाता है या ऊर्जा परिवर्तित होती है।

शक्ति की वैज्ञानिक इकाई वाट (W) है, जो एक जूल प्रति सेकंड के बराबर है।

The equation for power is $P = W/t$

- *P stands for power (in watts)*
- *W stands for the amount of work done (in Joules) or energy expended (in Joules)*
- *t stands for the amount of time (in seconds)*

शक्ति के लिए समीकरण $P = W/t$ है

P का अर्थ है शक्ति (वाट में)

W काम की राशि (जूल में) या ऊर्जा व्यय (जूल में) के लिए खड़ा है

T समय की राशि के लिए खड़ा है (सेकंड में)

Power

$w = mg = 9000N$

$v_0 = 0$

$P = ?$

$t = 5.6s$

$(1hp = 746W)$

$v_f = 20m/s$

$W = F \cdot d$

$W = \Delta E$

$$P = \frac{W}{t} = \frac{\Delta KE}{t} = \frac{\frac{1}{2}mv_f^2}{t}$$

$$m = \frac{w}{g}$$

$$\vdots$$

$P = 44hp$

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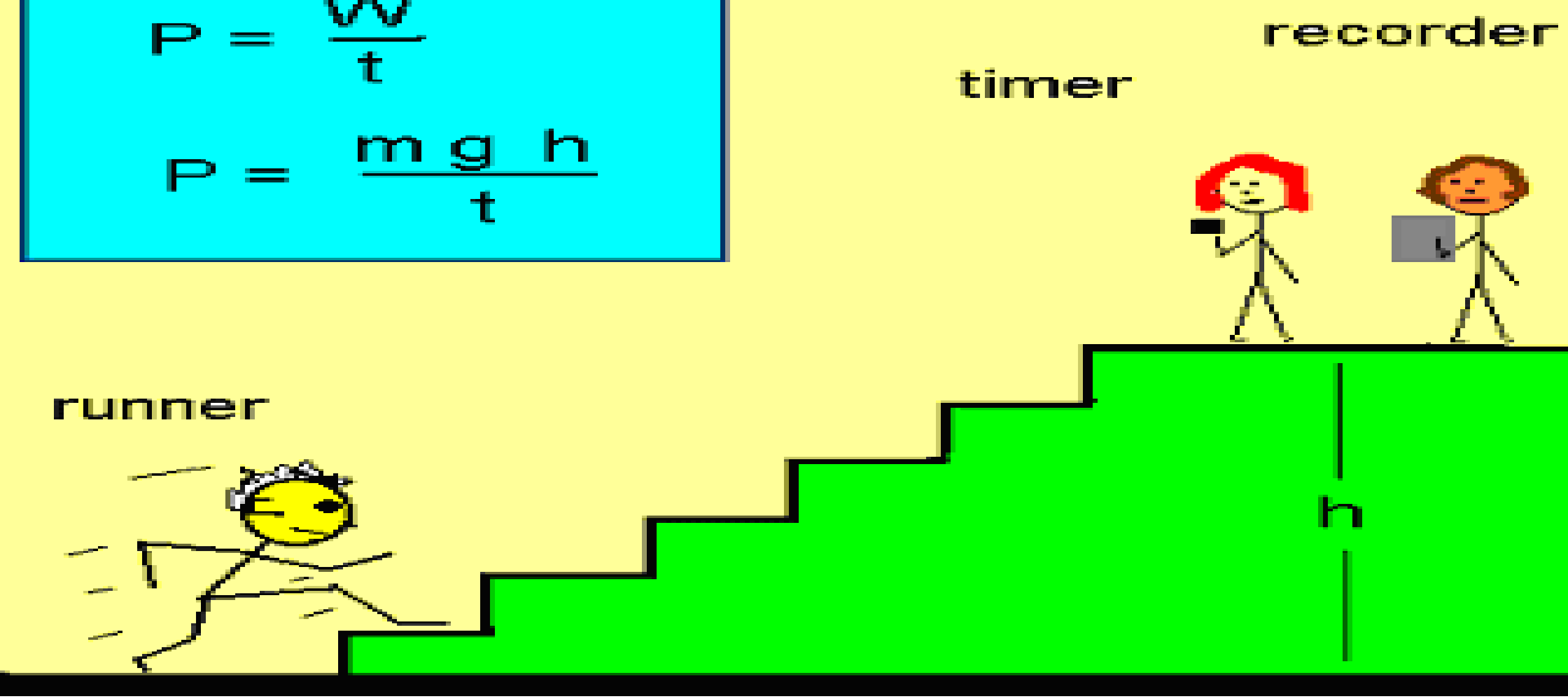
$$P = \frac{W}{t}$$

$$P = \frac{m\ g\ h}{t}$$



Multiple-choice questions

Choose just one answer: A, B, C or D.

1 A man does 600 J of work in pushing a child in a toy truck for 15 m. What force does he exert? **(1 mark)**

A 400 N
B 40 N
C 4 N
D 9000 N

2 Select the correct definition of power. **(1 mark)**

A power is the amount or work done
B power is the rate of energy transfer
C power is the force exerted when doing work
D power is the maximum energy transfer

3 The Watt, the unit of power, is defined as a: **(1 mark)**

A J/s
B Nm
C kgm/s
D kgm/s^2

4 Which of the following does not affect thinking distance? **(1 mark)**

A speed
B tiredness of the driver
C condition of the brakes
D distraction of the driver

5 How much energy is transferred in 6 s at a power of 1.5 kW? **(1 mark)**

A 4 J
B 9000 J
C 250 J
D 4 kJ

Energy & Power

Energy is the capacity to do work. Energy is power integrated over time. Power is the rate at which work is done, or energy is transmitted. Unit. joules = watt-seconds or joule = Newton-meter.

ऊर्जा कार्य करने की क्षमता है। समय के साथ ऊर्जा एकीकृत होती है। शक्ति वह दर है जिस पर काम किया जाता है, या ऊर्जा प्रसारित की जाती है। यूनिट। जूल = वाट-सेकंड या जूल = न्यूटन-मीटर।

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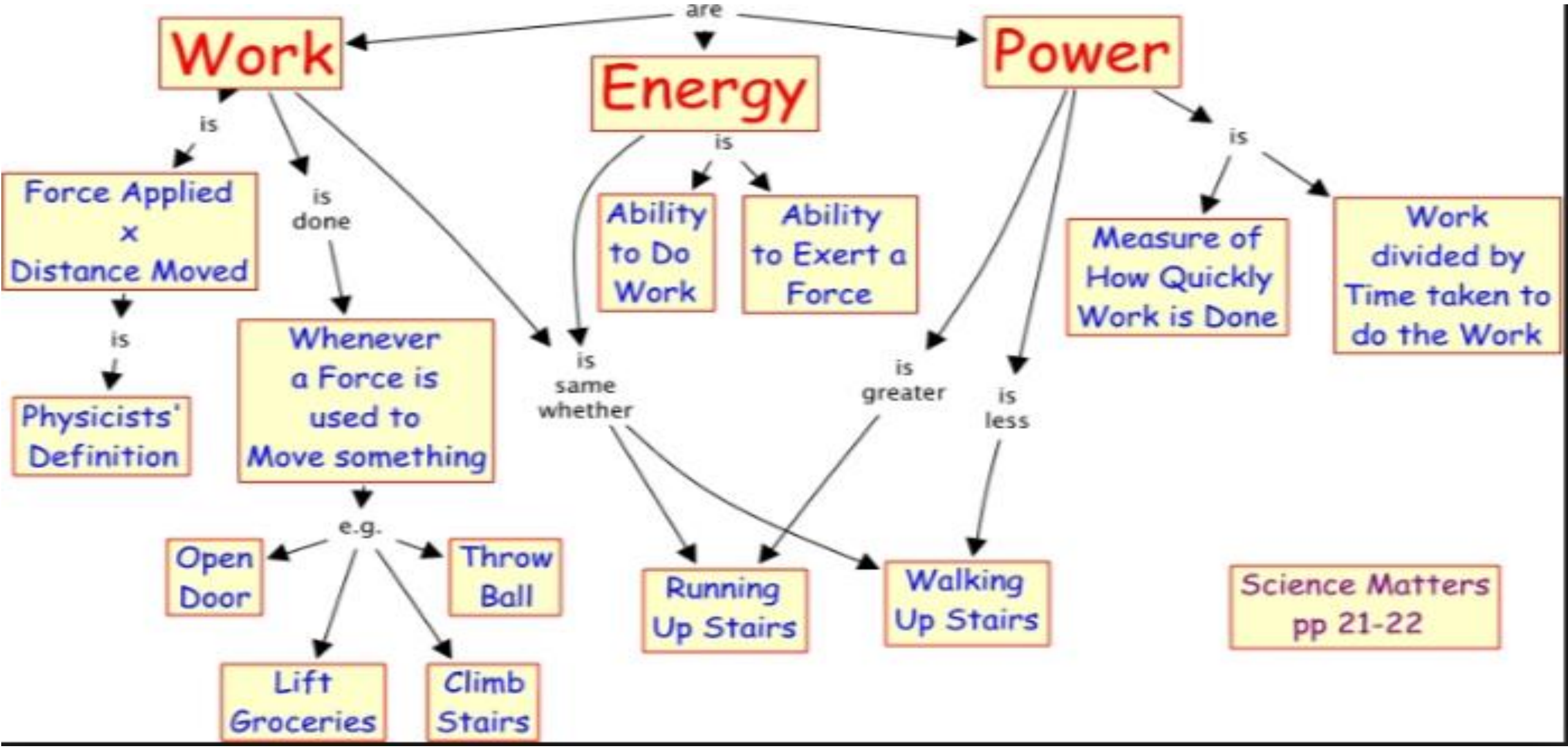

COLLISION

A **collision** is the event in which two or more bodies exert forces on each other in about a relatively short time. Although the most common use of the word **collision** refers to incidents in which two or more objects **collide** with great force, the scientific use of the term implies nothing about the magnitude of the force.

एक टक्कर वह घटना है जिसमें दो या दो से अधिक निकाय अपेक्षाकृत कम समय में एक दूसरे पर बल डालते हैं। यद्यपि शब्द टकराव का सबसे आम उपयोग उन घटनाओं को संदर्भित करता है जिसमें दो या दो से अधिक वस्तुएं बड़ी ताकत से टकराती हैं, शब्द के वैज्ञानिक उपयोग से तात्पर्य है कि बल के परिमाण के बारे में कुछ नहीं।

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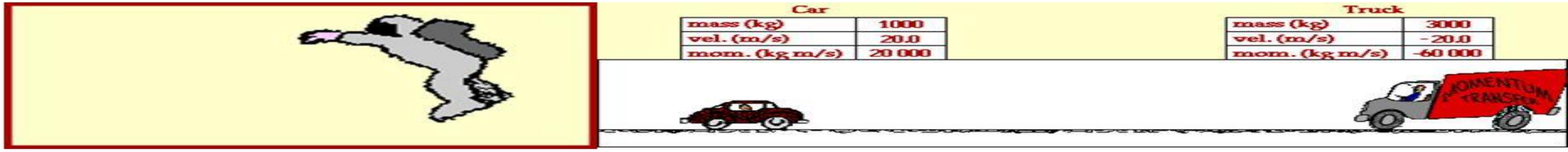
There are two general types of collisions in physics: elastic and inelastic. An inelastic collisions occurs when two objects collide and do not bounce away from each other.

Types of collisions



Car	
mass (kg)	1000
vel. (m/s)	20.0
mom. (kg m/s)	20 000

Truck	
mass (kg)	3000
vel. (m/s)	-20.0
mom. (kg m/s)	-60 000

Inelastic collision

elastic collision

Diesel	
Vel. (km/hr)	5
Mom. (kg km/hr)	40 000

Flatcar	
Vel. (km/hr)	0
Mom. (kg km/hr)	0

Car	
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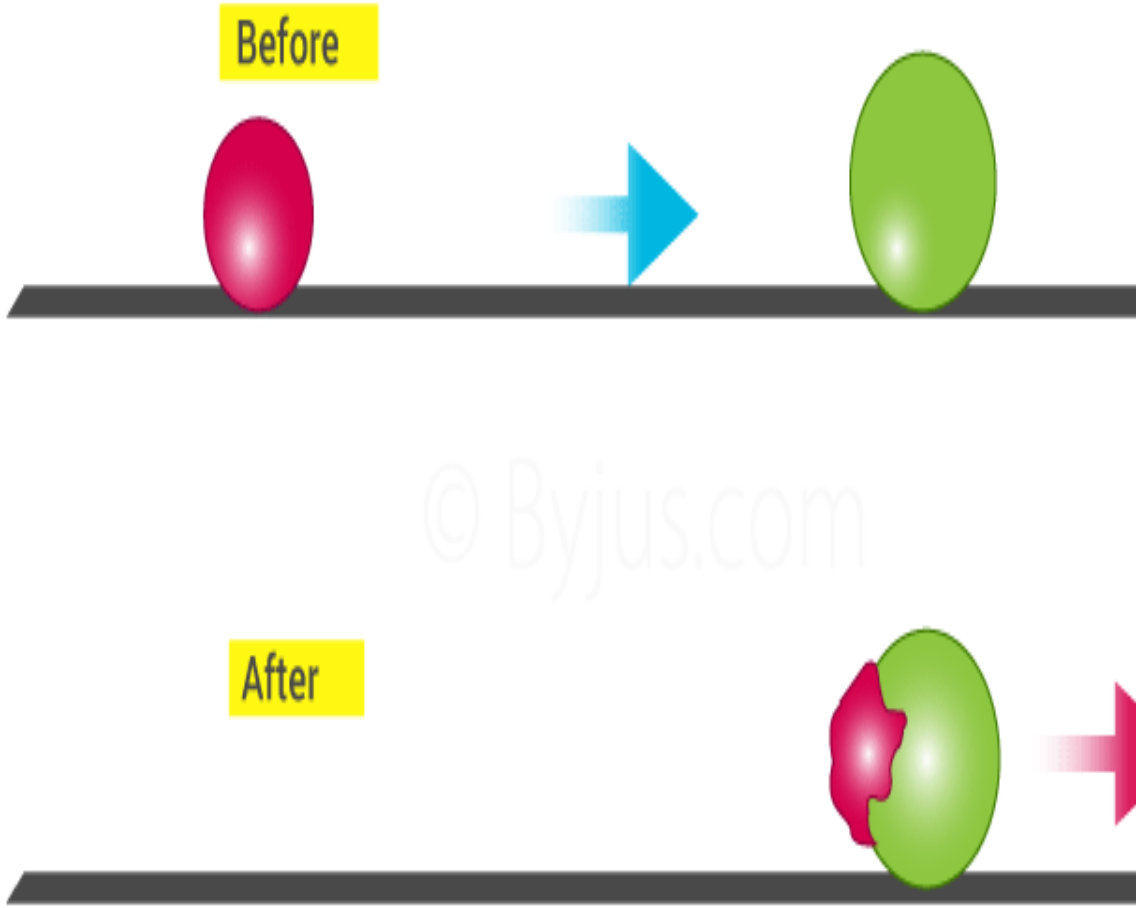
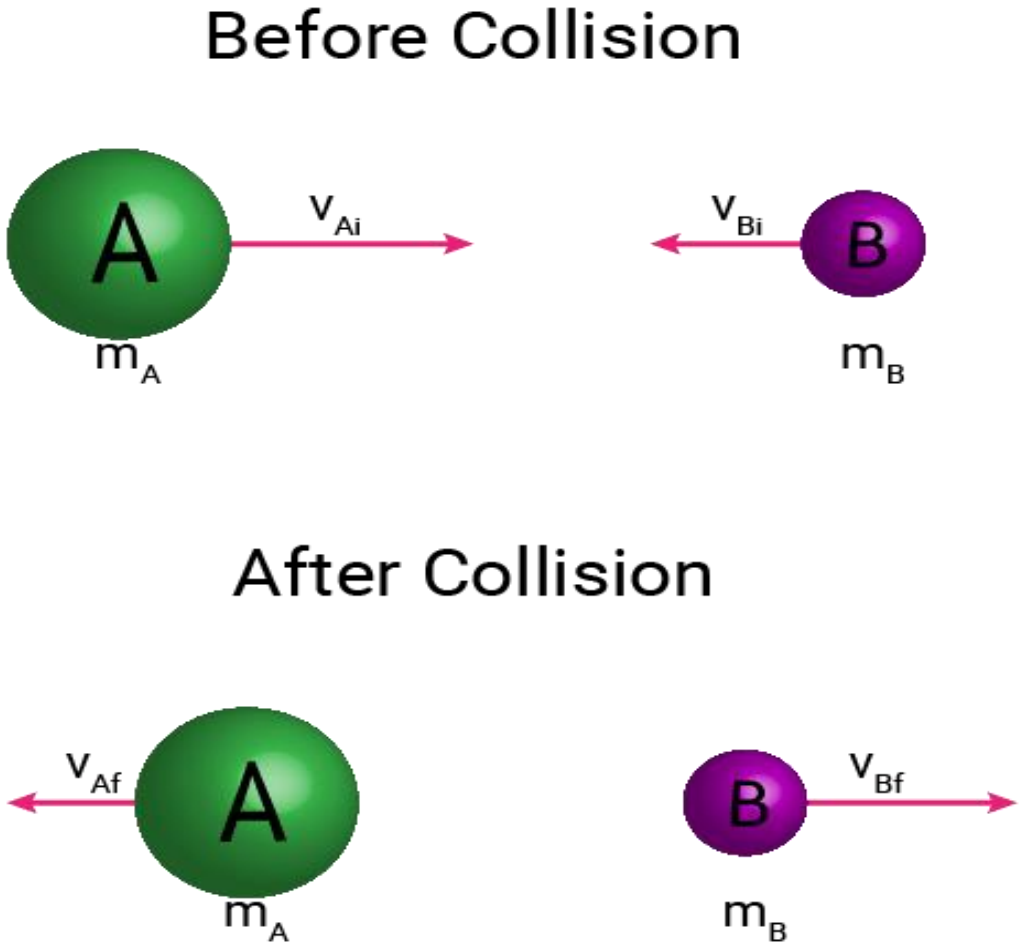
Inelastic collision

elastic collision

INELASTIC COLLISION



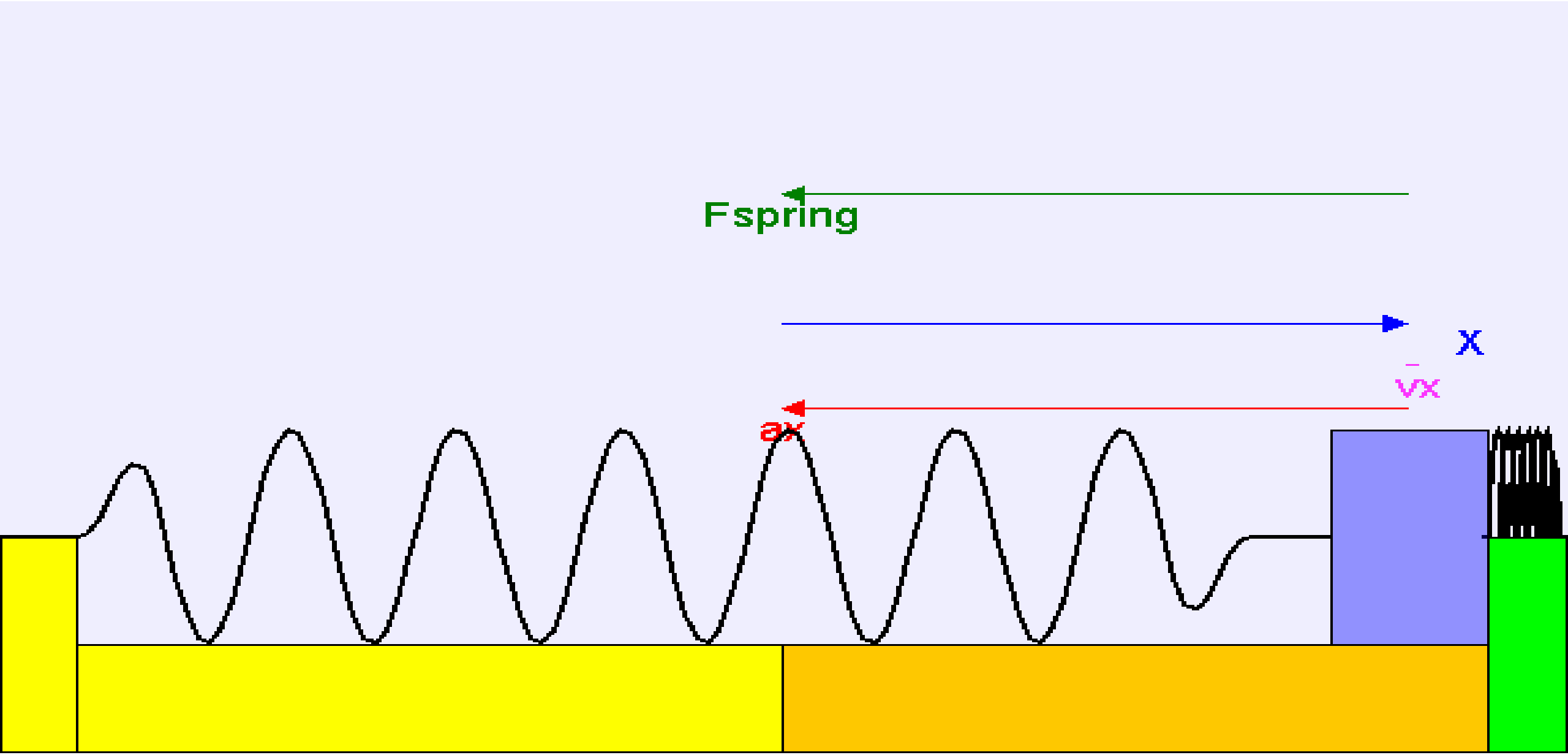


There are three different kinds of collisions, however, elastic, inelastic, and completely inelastic. Just to restate, momentum is conserved in all three kinds of collisions

Conservation Of Momentum
Momentum is conserved in all three types of collisions

- **Elastic:** Collide and separate; *KE* conserved
- **Inelastic:** Collide then separate deformed
  KE is **not** conserved

Perfectly Inelastic: Collide and stick together, then move with common velocity.
KE is **not** conserved


Fspring
x
vx
ax

Spring constant is a measure of the stiffness of spring up to its limit of proportionality or elastic limit

spring स्थिरांक एक spring की कठोरता की माप है जो आनुपातिकता या लोचदार सीमा तक सीमित है

$F\alpha -x$ Or F=-kx

When we pull the spring to a displacement of x as shown in the figure, the work done by the spring is :

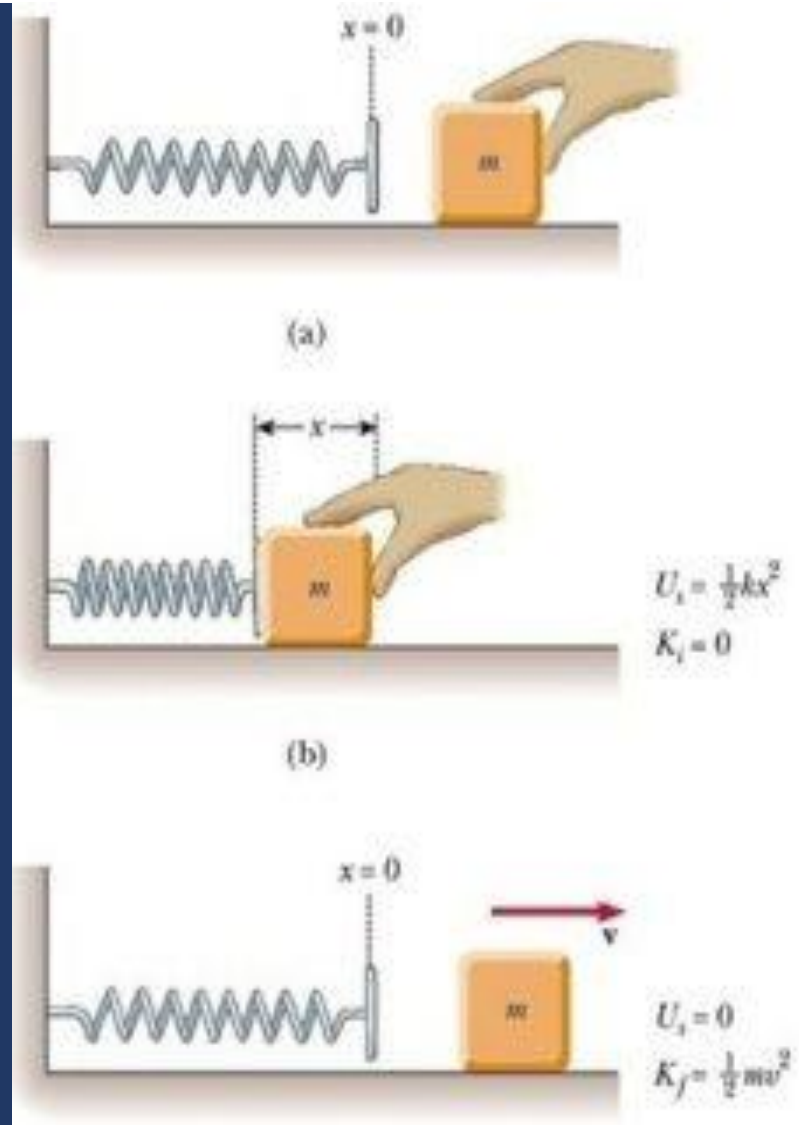
$$W = \int F dx$$

$$W = -\int kx\, dx = -k\frac{x^2}{2}$$

The work done by pulling force F_p is :

$$U = W = k\frac{x^2}{2}$$

This is the energy stored in the sretched spring.



जबहमएक्सकोविस्थापनकेलिएस्प्रिंगकोखींचतेहैंजैसाकिचित्रमेंदिखायागयाहै, वसंतद्वाराकियागयाकार्यहै:

$$W = \int F dx$$

$$W = -\int kx\, dx = -k\frac{x^2}{2}$$

बलFp खींचकरकियागयाकार्यहै:

$$U = W = k\frac{x^2}{2}$$

यहकटाहुआ spring मेंसंग्रहीतऊर्जाहै।

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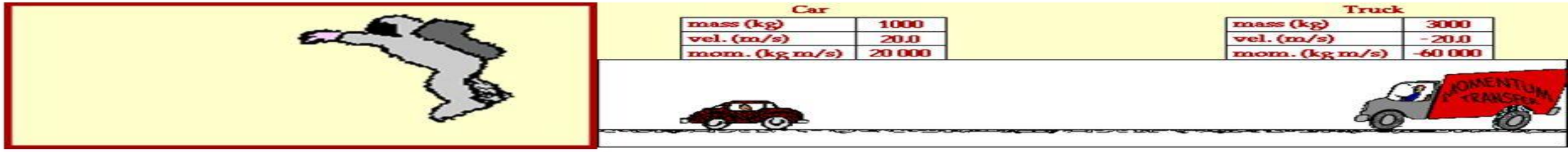

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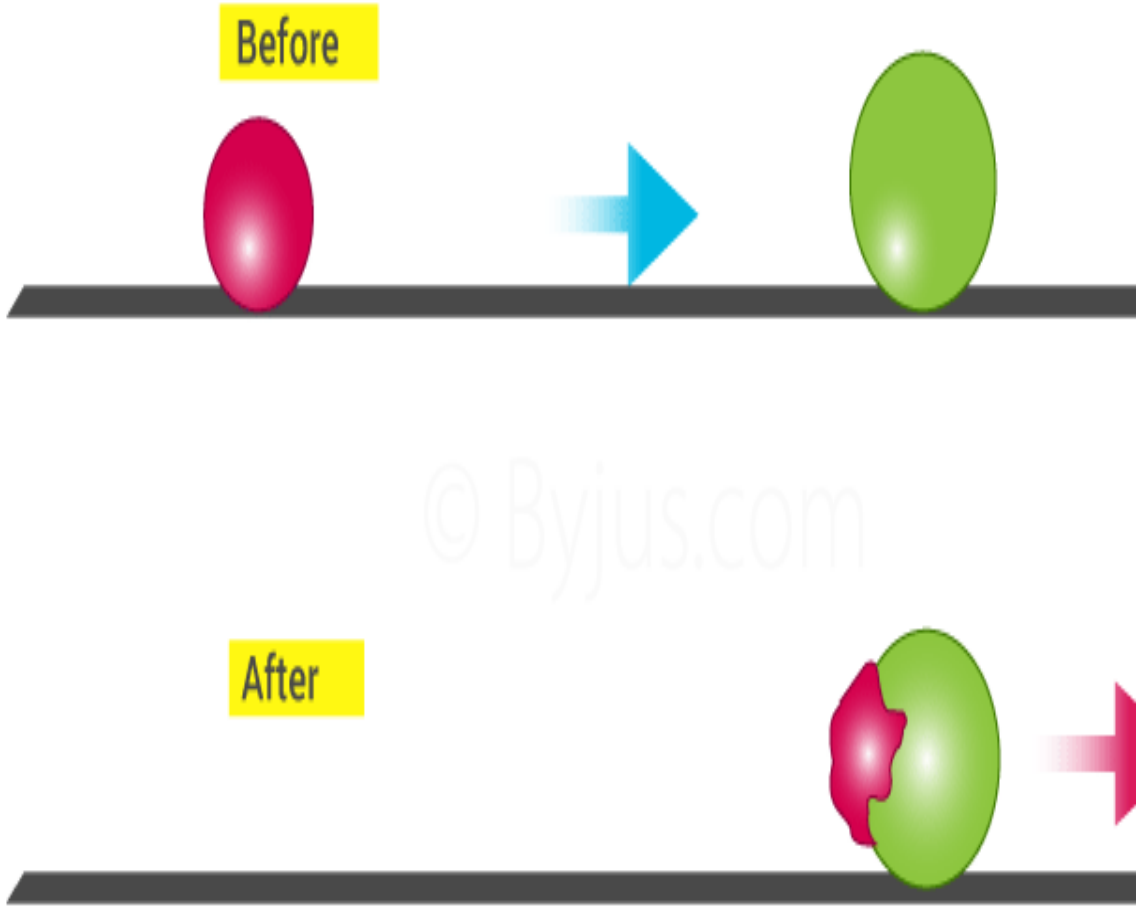
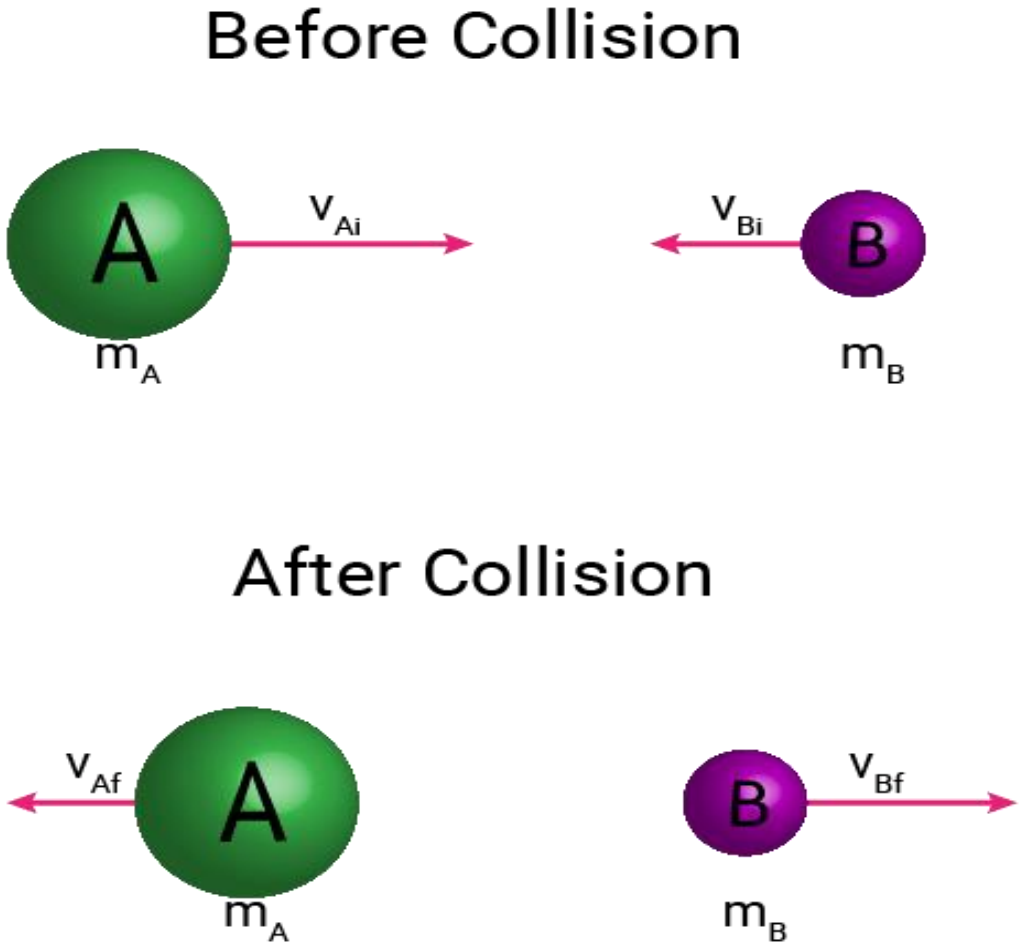
Inelastic collision

elastic collision

INELASTIC COLLISION





There are three different kinds of collisions, however, elastic, inelastic, and completely inelastic. Just to restate, momentum is conserved in all three kinds of collisions

Conservation Of Momentum
Momentum is conserved in all three types of collisions

- **Elastic:** Collide and separate; *KE* conserved
- **Inelastic:** Collide then separate deformed
  KE is **not** conserved

Perfectly Inelastic: Collide and stick together, then move with common velocity.
KE is **not** conserved

COEFFICIENT OF RESTITUTION FORMULA

The coefficient of restitution is the ratio between the relative velocity of colliding masses before interaction to the relative velocity of the masses after the collision. Represented by 'e', the coefficient of restitution depends on the material of the colliding masses.

$$\frac{V_2 - V_1}{U_1 - U_2} = e = \sqrt{\frac{h_{final}}{h_{initial}}}$$

If there is x% increase in momentum

Than % increase in KE will be:-

For eg:- ***Kinetic energy of a particle is increased by 300%. Find the percentage increase in its momentum.***

Solution

When the kinetic energy increase by 300 %, new kinetic energy will be K'=K+300 K

K'=K+3K

K'=4K

Here, $k = \frac{p^2}{2m}$

$\frac{p'^2}{2m} = 4.\frac{p^2}{2m}$

Hence,

$$P'^2 = 4P^2$$

Therefore, $P' = 2P$

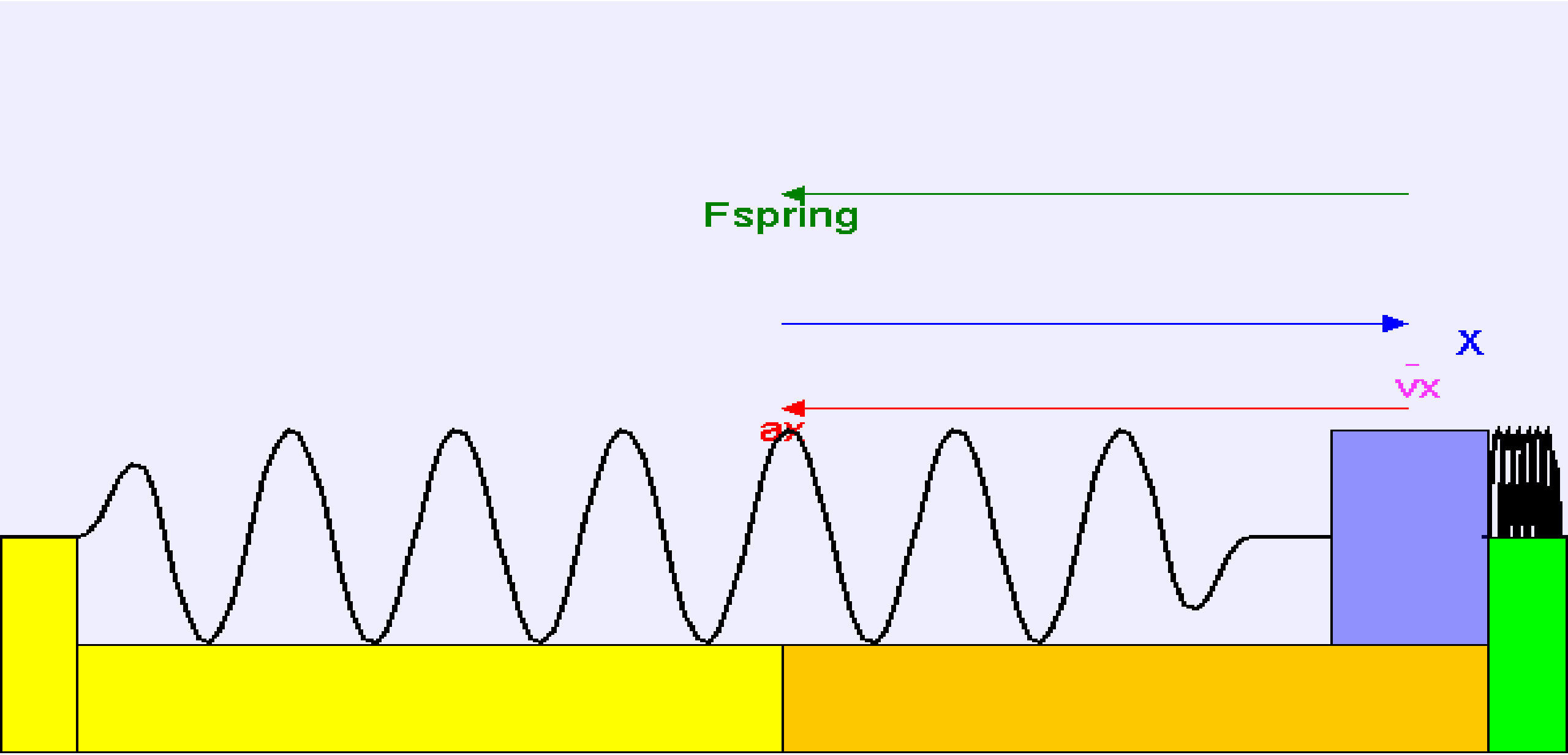
$$\% \text{ change in momentum} = \frac{P' - P}{p} \times 100$$

$$\% \text{ change in momentum} = \frac{2P - P}{p} \times 100$$

$$\% \text{ change in momentum} = \frac{p}{p} \times 100 = 100\%$$

$$\%\ change\ in\ KE = (P^2 - 1) \times 100$$

$$\%\ change\ in\ P = (\sqrt{KE} - 1) \times 100$$


Fspring
x
vx
ax

Spring constant is a measure of the stiffness of spring up to its limit of proportionality or elastic limit

spring स्थिरांक एक spring की कठोरता की माप है जो आनुपातिकता या लोचदार सीमा तक सीमित है

$F\alpha -x$ Or F=-kx

When we pull the spring to a displacement of x as shown in the figure, the work done by the spring is :

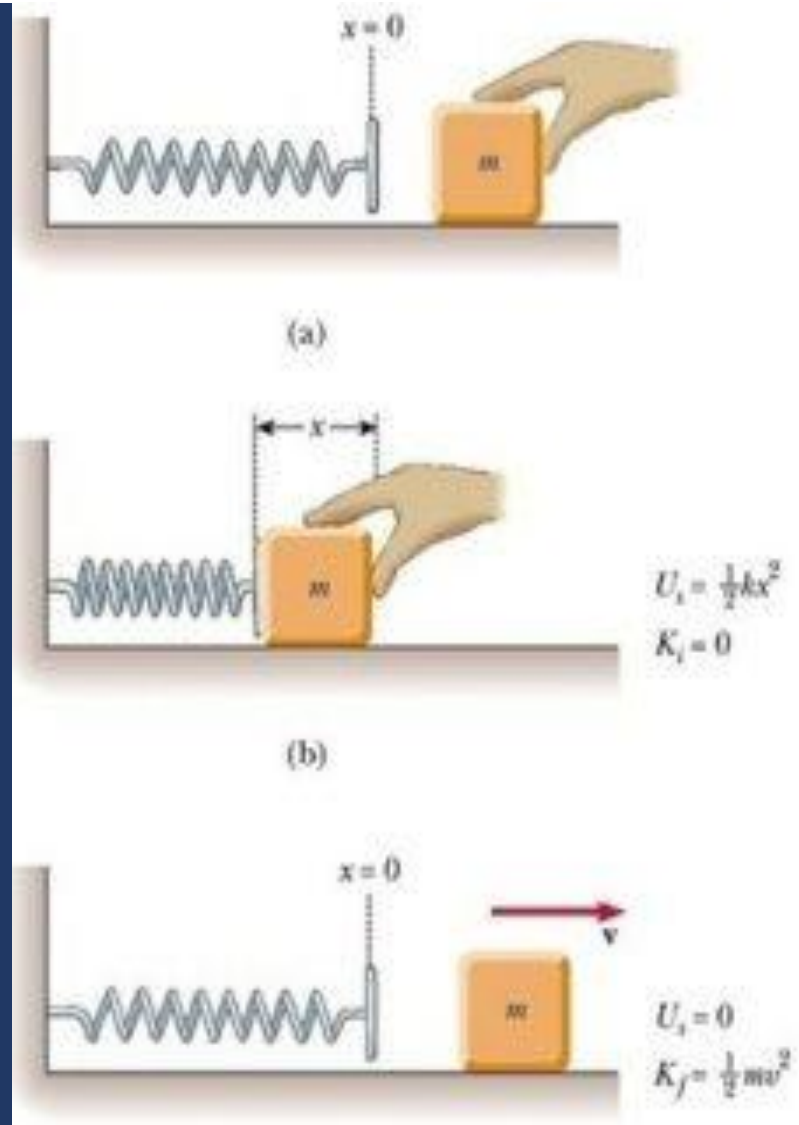
$$W = \int F dx$$

$$W = -\int kx\, dx = -k\frac{x^2}{2}$$

The work done by pulling force F_p is :

$$U = W = k\frac{x^2}{2}$$

This is the energy stored in the sretched spring.



जबहमएक्सकोविस्थापनकेलिएस्प्रिंगकोखींचतेहैंजैसाकिचित्रमेंदिखायागयाहै, वसंतद्वाराकियागयाकार्यहै:

$$W = \int F dx$$

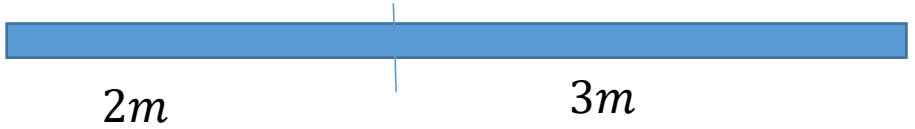
$$W = -\int kx\, dx = -k\frac{x^2}{2}$$

बलFp खींचकरकियागयाकार्यहै:

$$U = W = k\frac{x^2}{2}$$

यहकटाहुआ spring मेंसंग्रहीतऊर्जाहै।

*When a spring is cut into two parts there **kl** remains constant:-*



Total length of the wire is 5m,

Here $kl=\frac{2}{5}k_1 l=\frac{3}{5}k_2 l$

Q.0) If a man carries a mass of 10kg to the height of 100m in time 3hour, and the mass of the man is 0kg. Find his efficiency:-

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$$Efficiency = {}^{mass\ of\ the\ object}/_{total\ mass} \times 100$$