Chapter 6.
Energy Stores and Transfers

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New Words

Kinetic energy, gravitational potential energy, thermal energy, strain/elastic energy, chemical energy, internal energy, dissipated, steam, work, efficiency, filament lamp, ramp

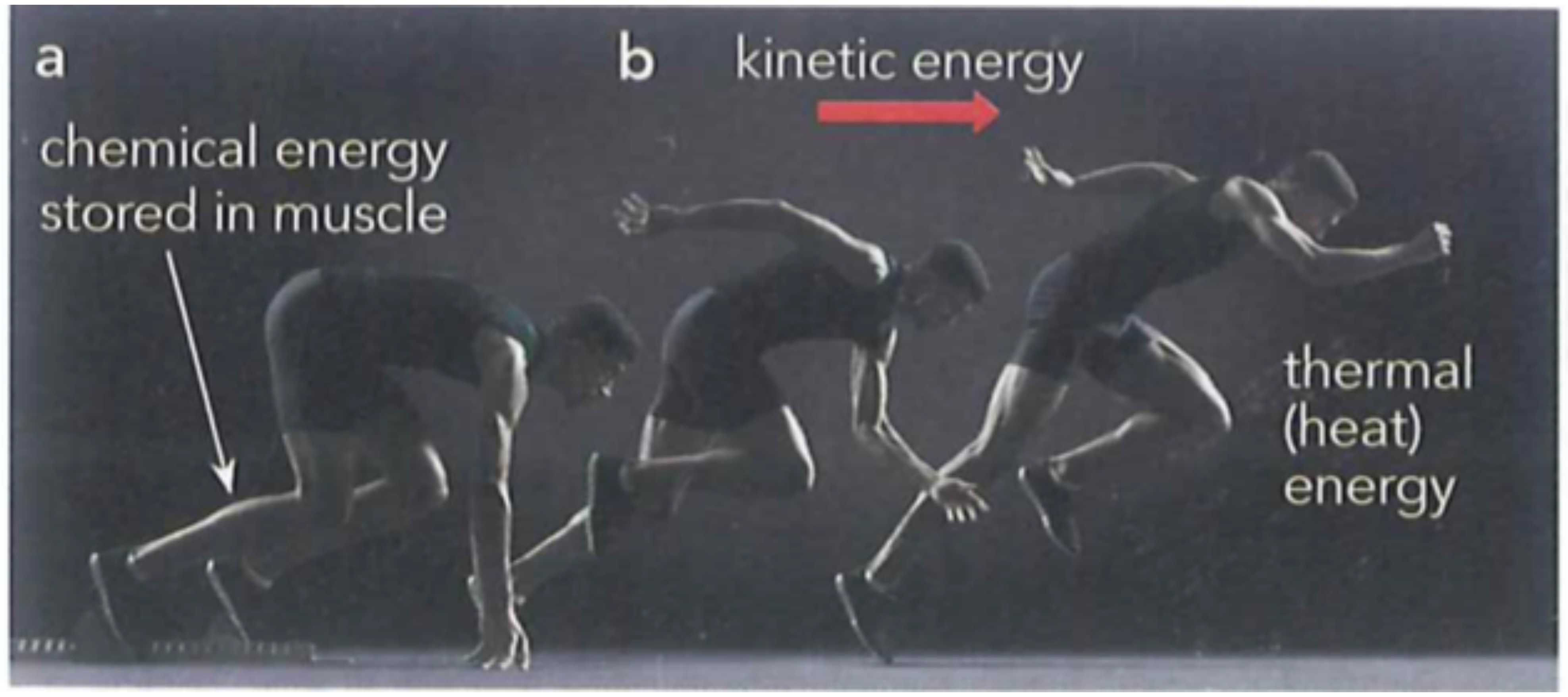
Energy

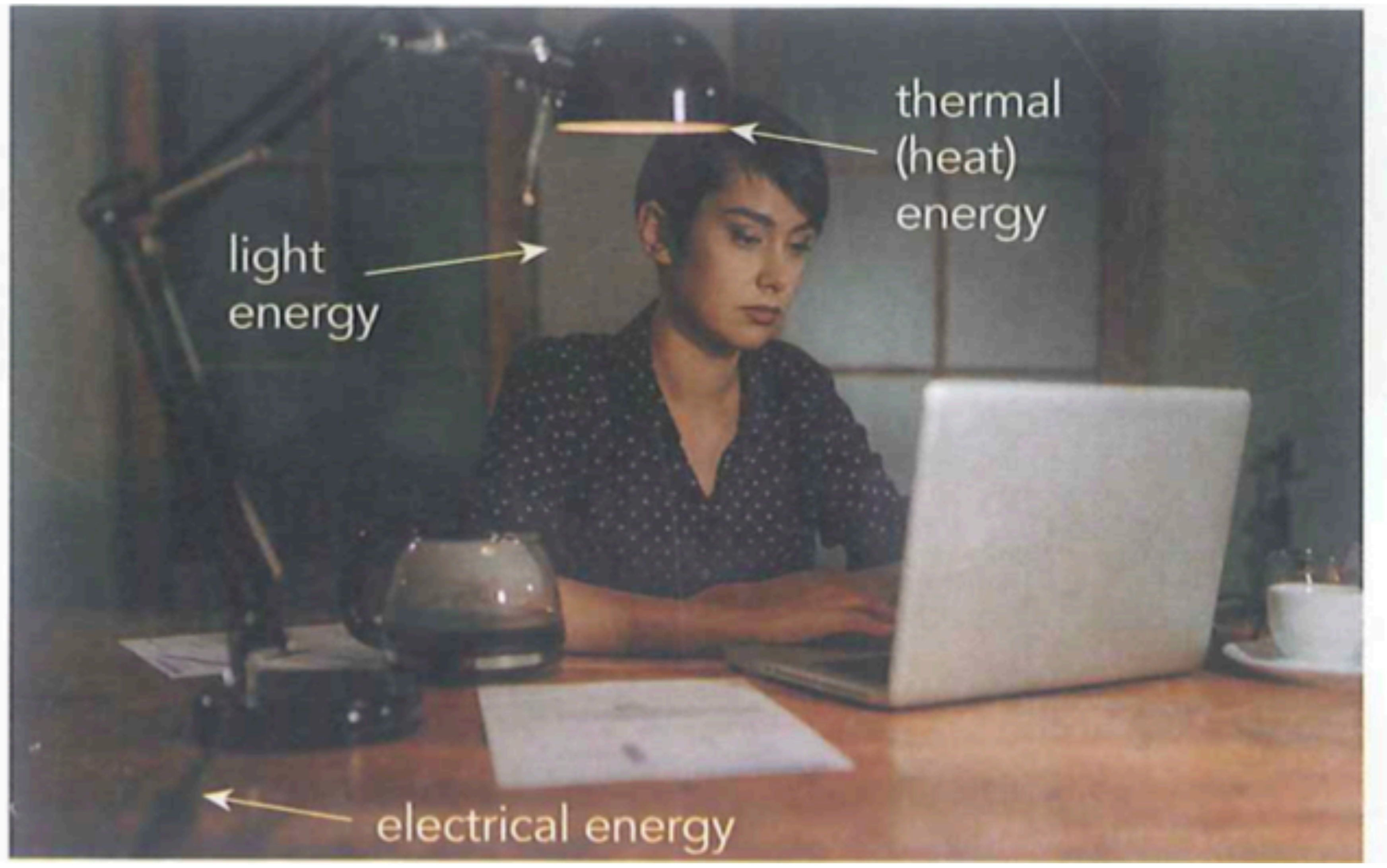
What do you think is the energy? Can you name some types of energy?

Energy: the ability to do work

Energy is a ***scalar***, unit: ***J*** (Joule)

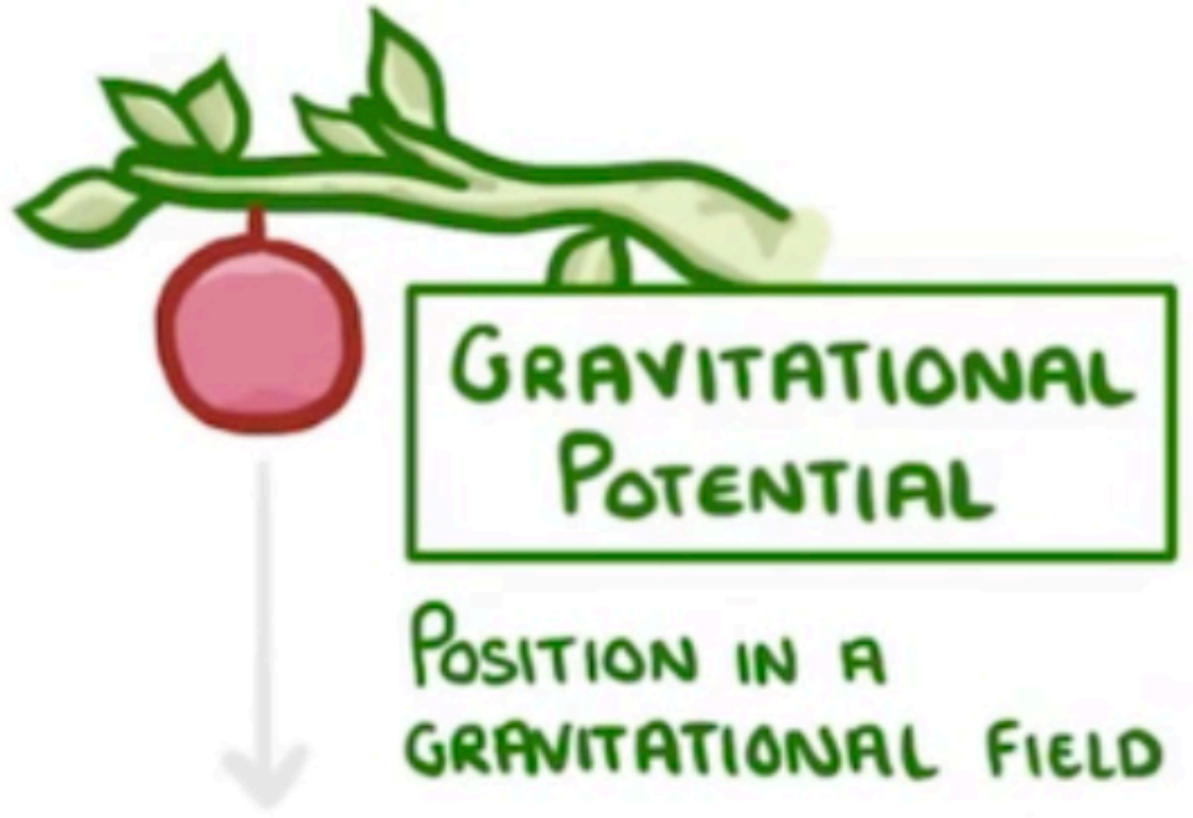
Think about the process of **running** and the event of **switching on a light**, what kinds of energy are involved in these situations?





Gravitational Potential Energy

Gravitational **potential** energy(g.p.e): energy due to **height**



★**Equation:** $E_p = mgh$

g.p.e. = Mass × gravitational field strength × height

Unit: J   1 J = 1Nm   Same as moment M; *Unit of* ***Impulse****?* ***Pressure****?*

Ground: E_p = 0   *Will you jump higher if you are on the Moon instead of the Earth?*

GPE depends on: Weight   W ↑ => g.p.e. ↑

Height   h↑ => g.p.e. ↑

- Above the ground
- Vertical height
- From the center of gravity

Gravitational Potential Energy

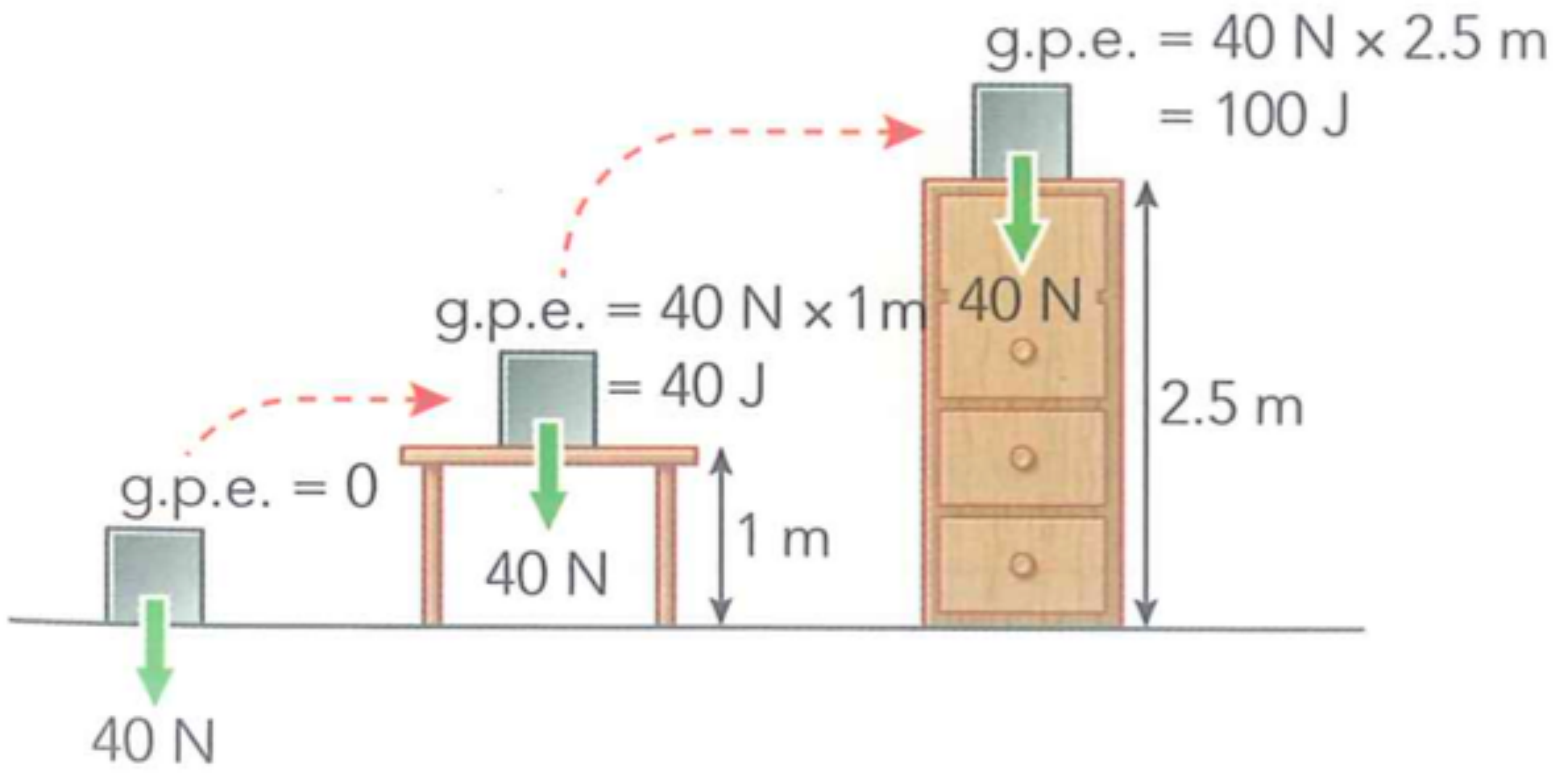
Gravitational **potential** energy(g.p.e): energy due to **height**

★**Equation:** $E_p = mgh$

g.p.e. = Mass × gravitational field strength × height

Change in g.p.e.:

$$\Delta E_p = mg\Delta h$$



Exercise

An athlete of mass 50kg runs up a hill. The foot of the hill is 400 meters above the sea-level. The summit is 1200 meters above sea-level. By how much does the athlete's g.p.e. increase?

Exercise

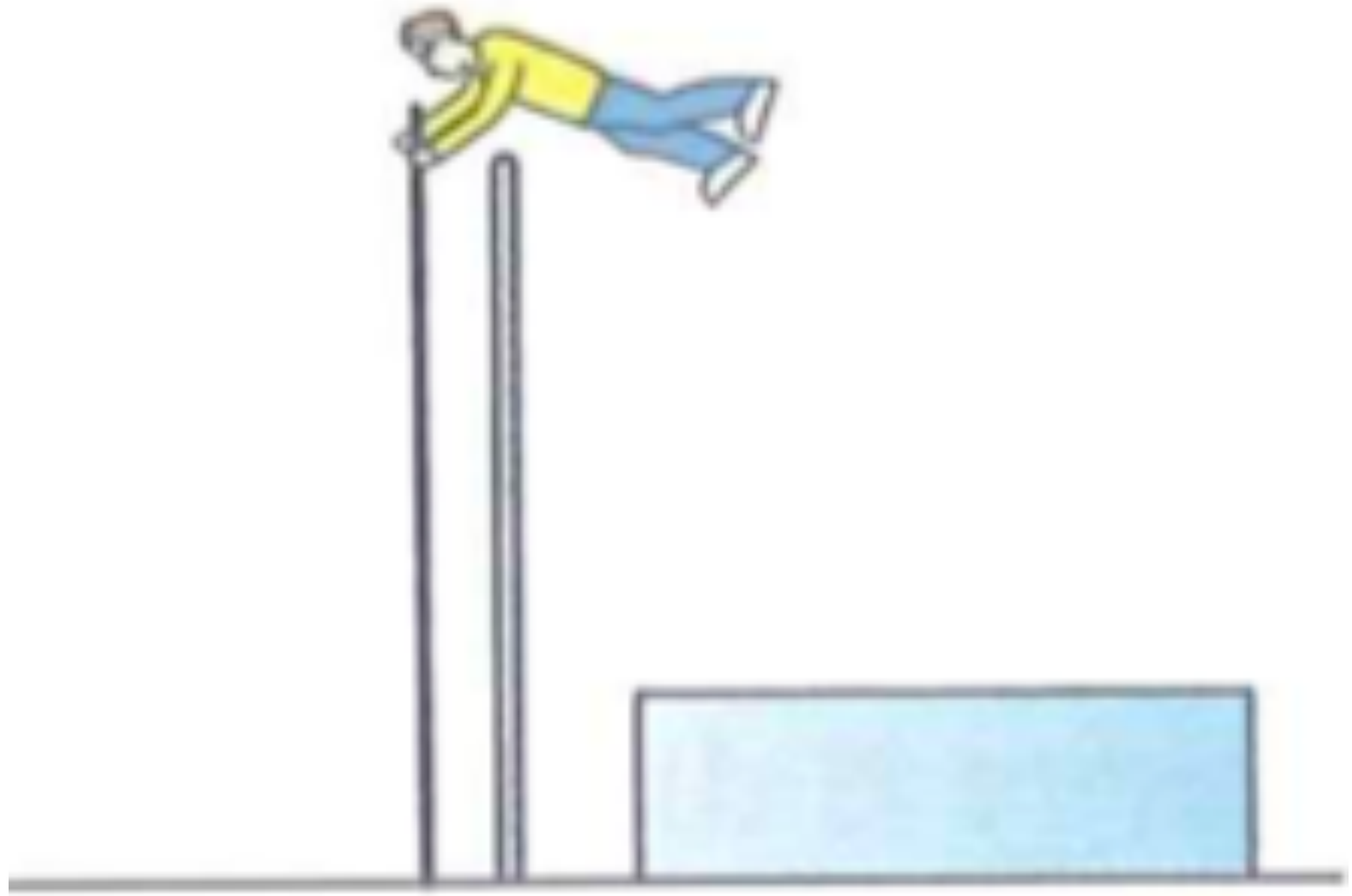
When a satellite is traveling around the Earth in a circular orbit. How does its g.p.e changes?

Exercise

An object of mass 1kg moves along up a ramp shown as below. By how much does its g.p.e. increase?

Exercise

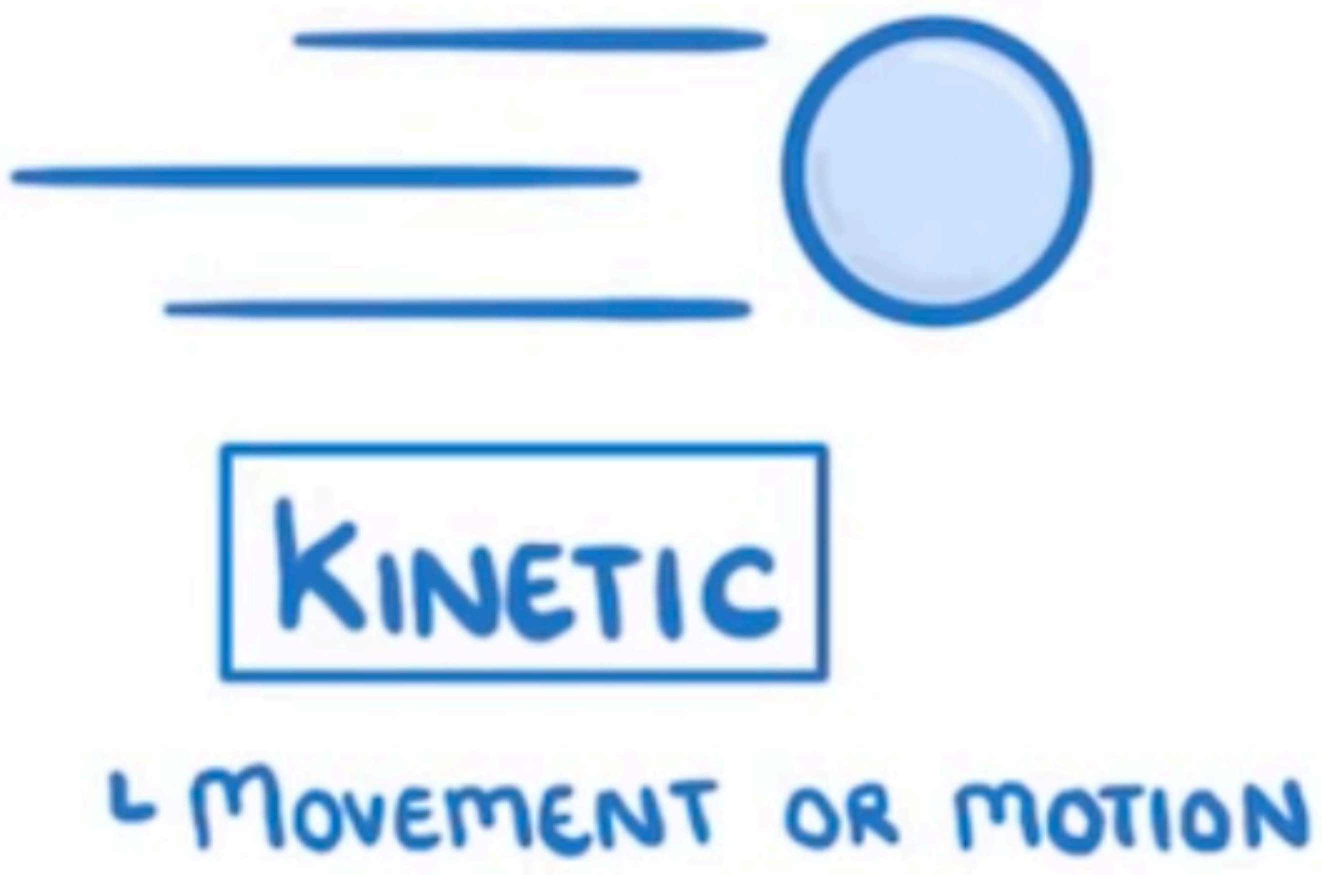
Why does pole-vaulters usually adopt a curved posture to get over the bar?



Kinetic Energy

Kinetic energy(k.e.): energy due to **motion**

★**Equation:** $E_k = \frac{1}{2}mv^2$



Unit: J 1 J = 1kgm^2/s^2

KE depends on: Speed: v↑ => k.e. ↑

Mass: m ↑ => k.e. ↑

Change in k.e.: $\Delta E_k = E_{kf} - E_{ki} = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 \neq \frac{1}{2}m\Delta v^2$

Exercise

A van of mass 2000kg is traveling at 10m/s.
Calculate its kinetic energy
Its speed increases to 20m/s. By how much does its kinetic energy increase?

Exercise

A ball of 5kg falls from rest for 10 seconds, how much kinetic energy does it gain? (ignore air resistance) How much gravitational potential energy does it lose? What information can you infer from this example?

Exercise

Planets usually move around stars in elliptical orbit. When it is closer to the star, does it speed increase or decrease? Why?

Other Energy Stores

Strain energy/elastic (potential) energy: energy due to **deformation** of an elastic object

$$E_p = \frac{1}{2}kx^2$$ (Not required)

depends on: compression/extension x ↑ => e.p.e. ↑

spring constant k↑ => e.p.e. ↑

Internal energy

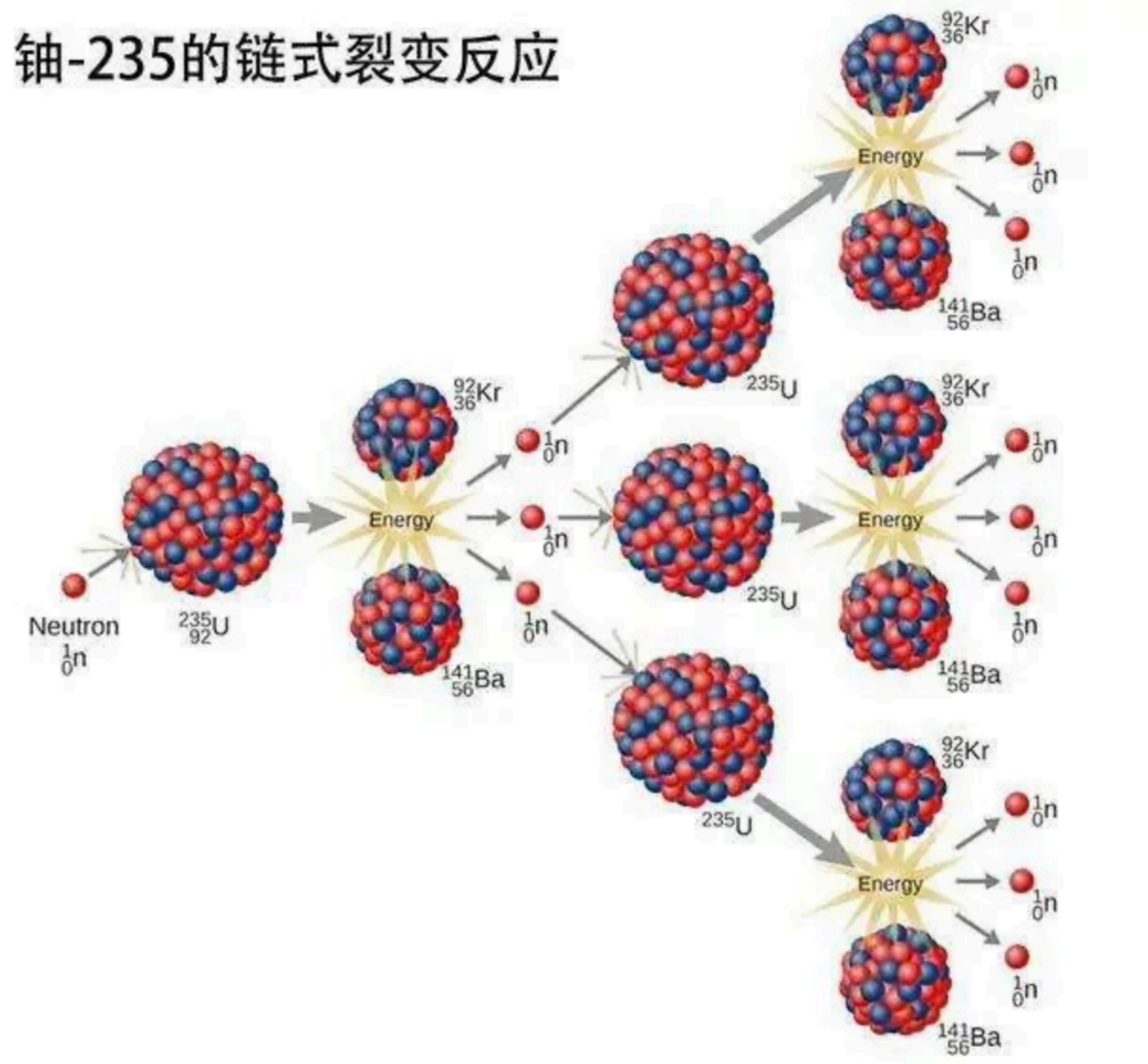
The energy of an object= **total** kinetic energy + **total** potential energy of **all** atoms in an object

Why does stream have more internal energy than boiling water?

Other Energy Stores

Chemical energy

Nuclear energy



Exercise

According to the physical clues on the left column, write down which energy store is changing.

Physical clue	Which energy store is changing?
material changing shape	
object changes speed	
chemical reaction	
change of temperature	
nuclear fission or fusion	
distance between objects changes	

能量转换：看看物体**状态**发生了什么**变化**，
对应什么**能量**改变
h => g.p.e.;
v =>k.e.;
change size/shape => elastic energy;
T => internal/thermal;
nuclear reaction =>nuclear energy;
chemical reaction => chemical energy

Energy Store Summary

Gravitational potential energy(g.p.e.): energy due to height; $E_p = mgh$; $\Delta E_p = mg\Delta h$

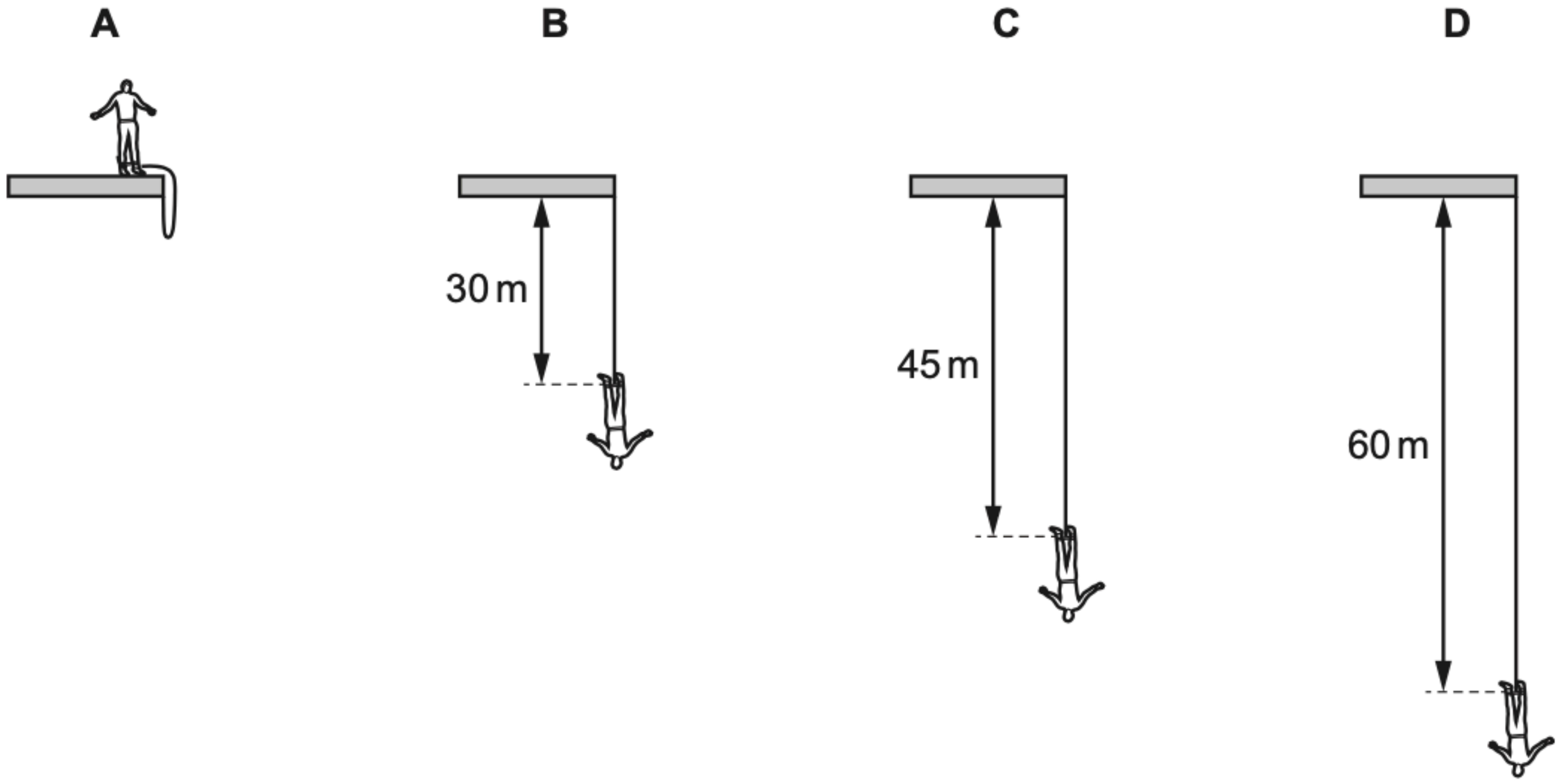
Kinetic energy(k.e.): energy due to motion $E_k = \frac{1}{2}mv^2$; $\Delta E_k = E_{kf} - E_{ki} = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

Elastic energy; Internal energy; Chemical energy; Nuclear energy; Electrical energy

A man, attached to an elastic cord, jumps from a platform. He falls 60 m before starting to rise. The length of the unextended cord is 30 m.

The diagrams show four successive stages in his fall.

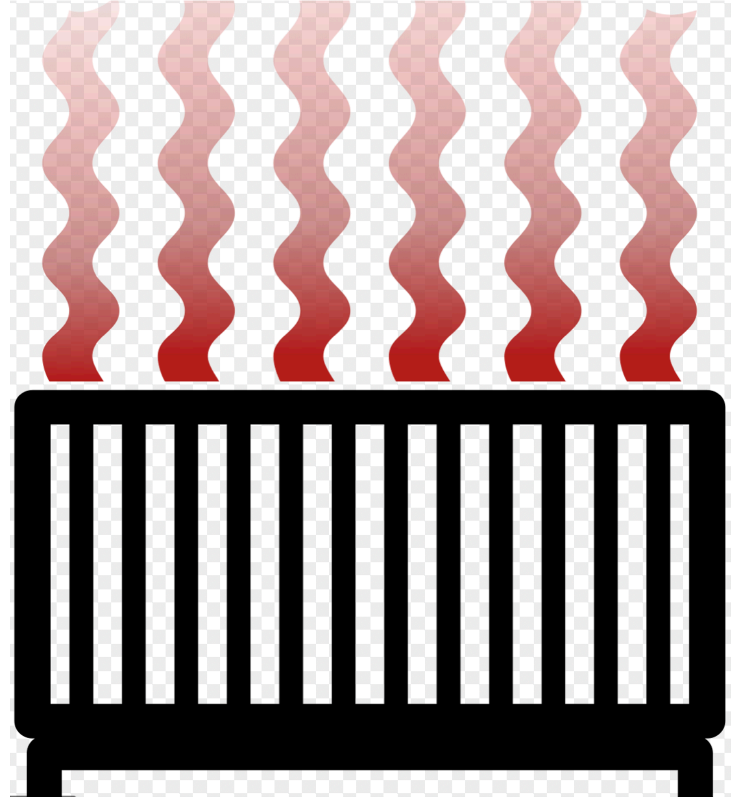
In which position is elastic (strain) energy and kinetic energy present?



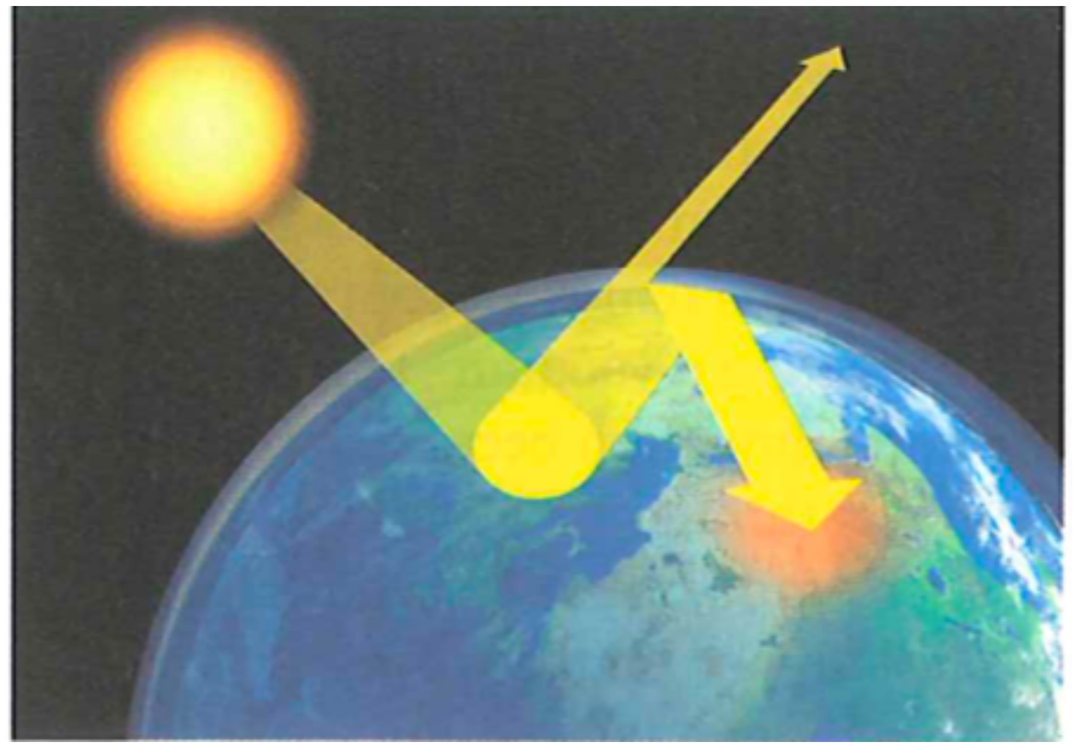
Energy Transfers

- Doing work (mechanical working)

- Heating (thermal working)

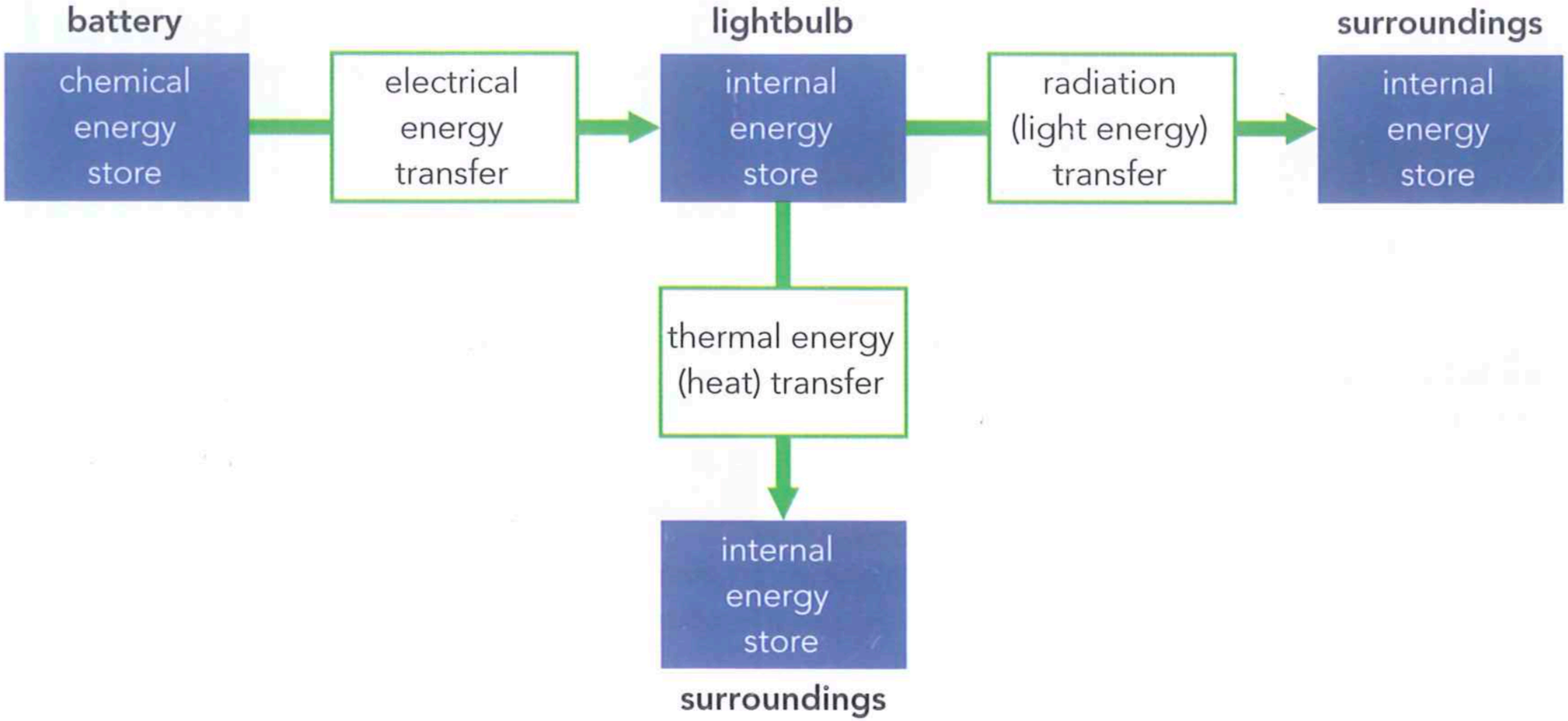


- Radiation (light)

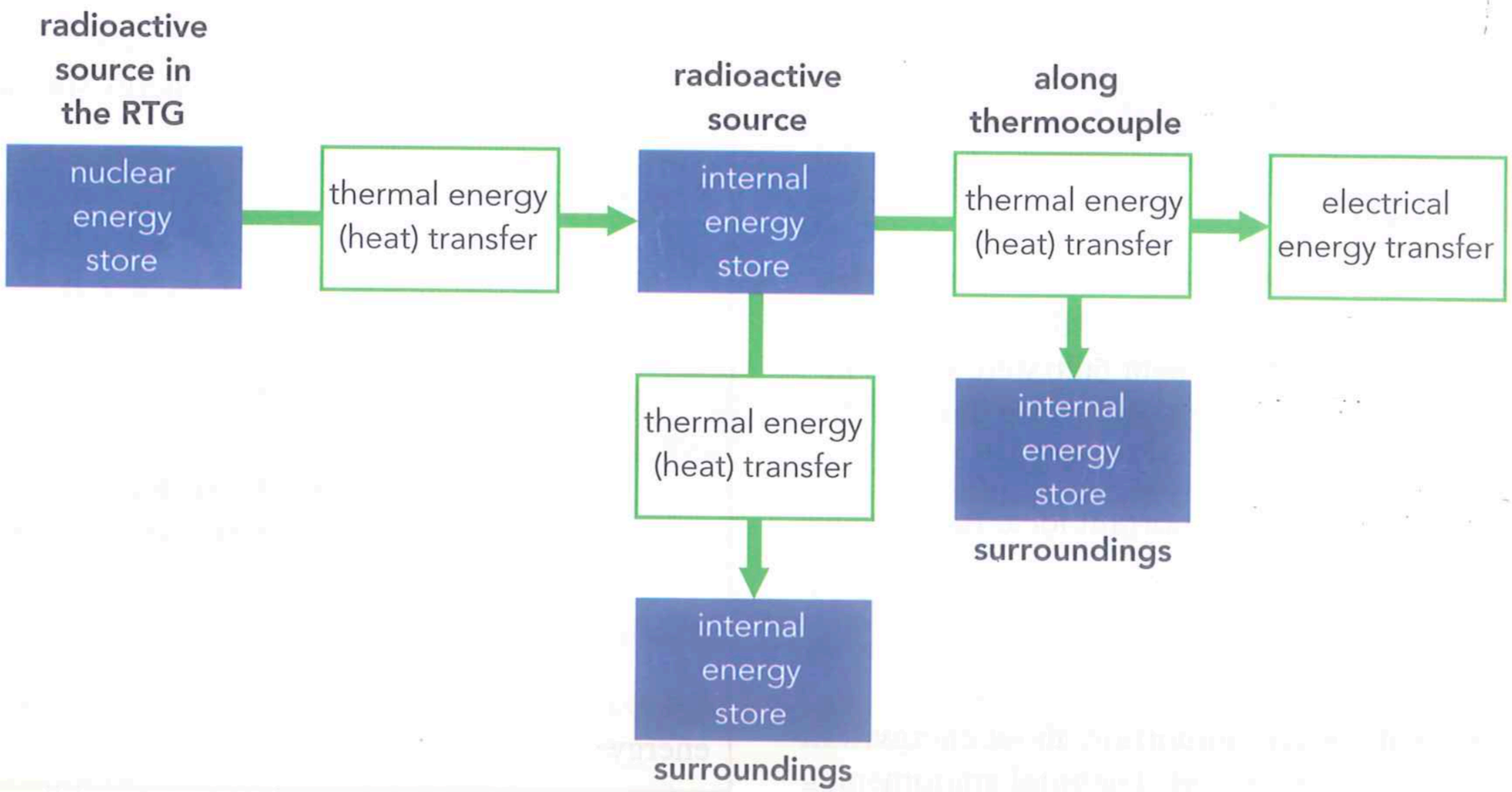


- Electrical currents(electrical working)

Energy Transfers

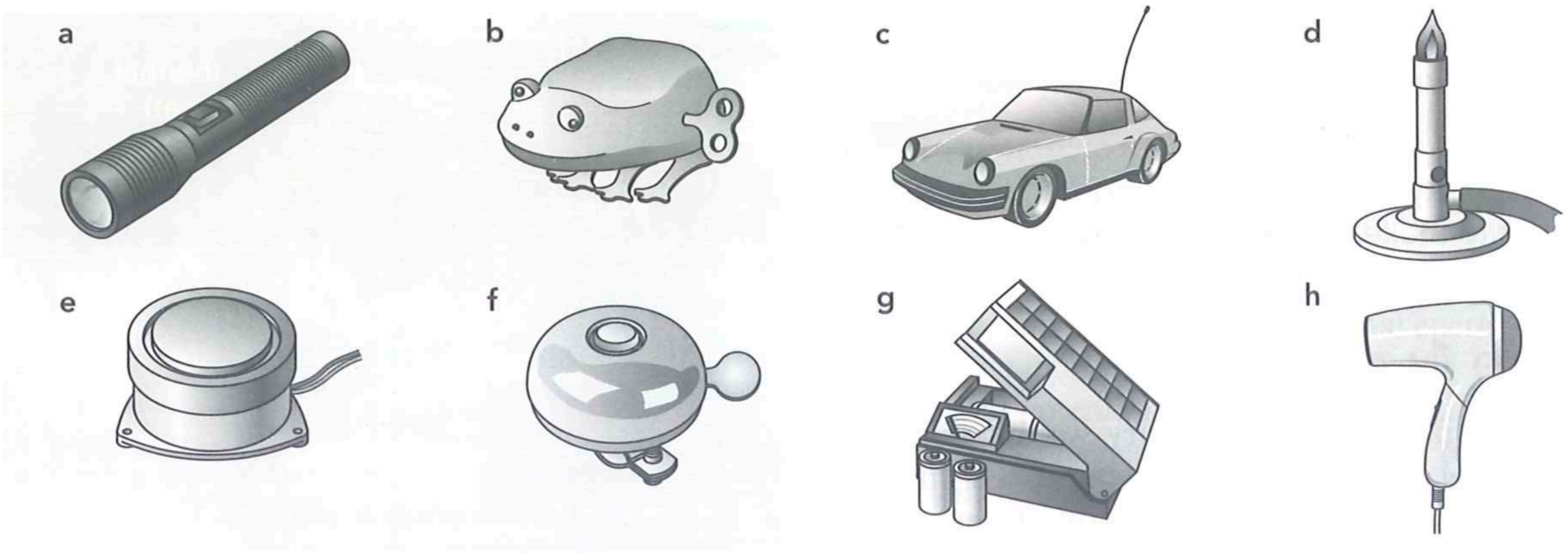


Energy Transfers



Exercise

Can you explain how energy transfers in the following situations?



Energy Conservation

★**Principle of energy conservation:**

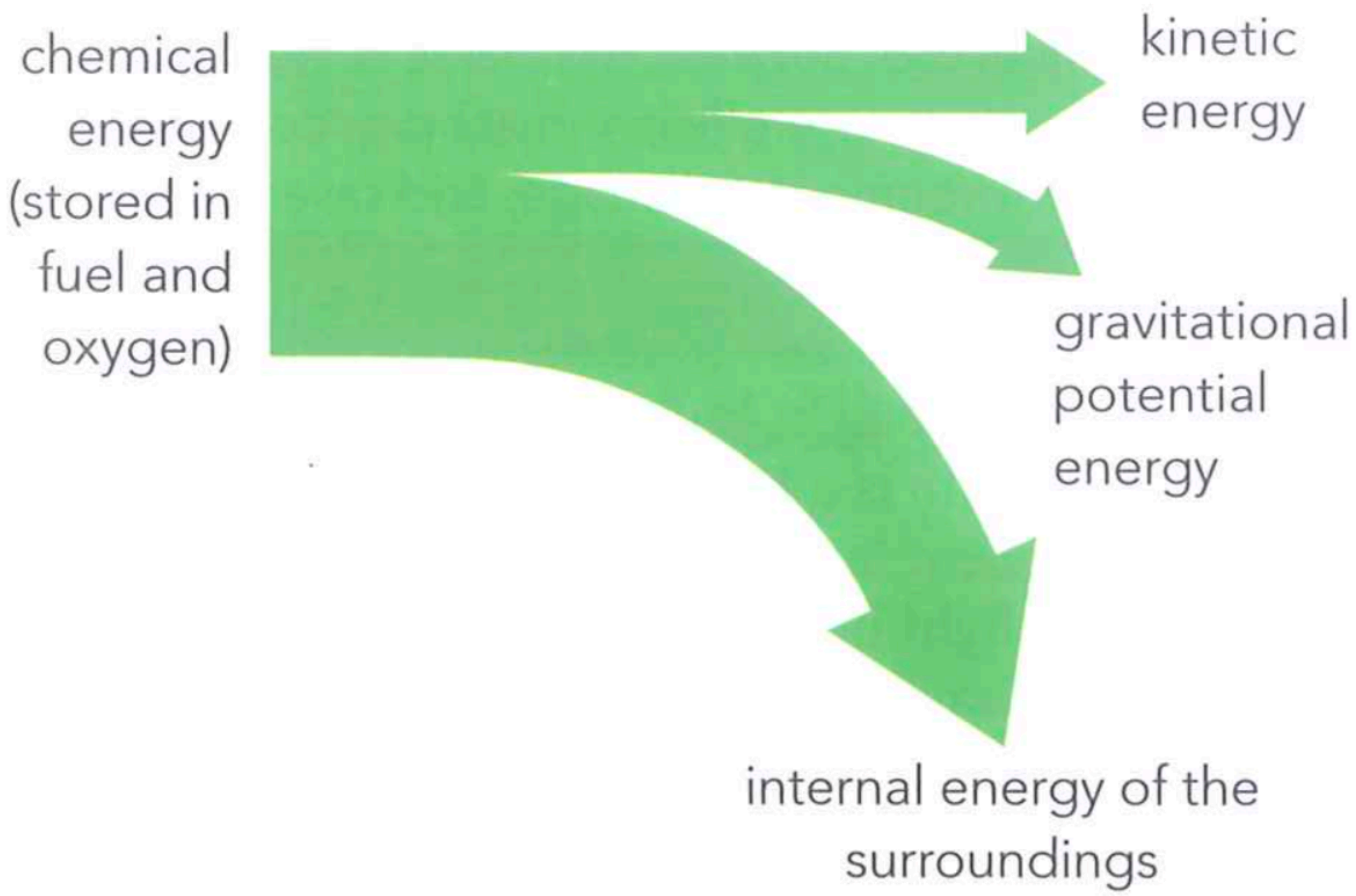
In any energy **transfer**,
the total amount of energy before and after transfer is **constant**

Exercise

A car burns 300000J of fuel per second. It has 130000J of kinetic energy and gain 70000J of gravitational potential energy as it goes up a slope. How much energy transfers away from the car through thermal energy transfer?

Sankey Diagram

A flow of diagram representing energy conservation. Arrow width proportional to energy. Total width remains constant.



Sankey diagram of launching a rocket.

Energy Efficiency

Energy dissipated: Energy that is spread out is not useful. (Wasted)

usually through: heat (work of friction, conduction), light, sound.

Energy efficiency: Efficiency $= \dfrac{useful\ energy\ output}{total\ energy\ input} = \dfrac{total\ energy - wasted\ energy}{total\ energy\ input}$

Percentage efficiency = Efficiency $\times 100\,\%$

When a filament lamp is supplied with 100J of energy, it produces 15J of useful light. What is its efficiency?