Core Idea PS3

Energy

How is energy transferred and conserved?

- interaction
- object
- explain
- predict
- concept: the transfer of energy from one object or system of objects to another
- total energy
- defined system
- changes only by the transfer of energy into or out of the system.

PS3.A: DEFINITIONS OF ENERGY

What is energy?

- defined quantity
- energy
- conservation of (a system's *total*) energy
- subsystems
- energy transfer
- macroscopic scale
    - energy manifestations (matter (energy=matter x speed of light^2), motion, light, sound, electrical and magnetic fields, and thermal energy)
- units for energy
- microscopic scale
    - energy manifestations (motions of particles, stored in force fields -- electric, magnetic, gravitational)
- particle(s) (atomic and subatomic)
- electromagnetic radiation (light, radio waves)
- space (void of matter)
- motion
- kinetic energy
- reference frame
- proportional
- mass
- matter
- temperature
- absolute zero
- thermal energy
- vibration(s)

- solid
- molecules
- free motion
- gas
- collision
- interactions/action/force at a distance
- sound wave
- pattern
- electric field
- magnetic field
- magnet(s)
- equilibrium position(s)
- atomic nuclei
- molecule
- chemical bond
- metal(s)
- stored energy
- potential energy
- spatial configuration
- gravitational field
- gravitational potential energy
- falling objects
- pendulum
- friction
- electromagnetic radiation (such as light and X-rays)
    - wave of changing electric and magnetic fields
- subatomic scale (i. e., in quantum theory)
- photoelectric effect
- photon(s)
- sun
- earth
- forms of energy (thermal energy, mechanical energy, and chemical energy)
- atomic scale
- radiation.

Grade Band Endpoints for PS3.A

By the end of grade 2. [Intentionally left blank.]

By the end of grade 5.

- faster
- object
- move(ing)
- energy (Boundary: At this grade level, no attempt is made to give a precise or complete definition of energy.)
- sound
- light
- electric currents

At the macroscopic scale, energy manifests itself in multiple phenomena, such as motion, light, sound, electrical and magnetic fields, and thermal energy.

By the end of grade 8.

- motion energy
- kinetic energy
- proportional
- mass
- system
- object(s)
- potential energy
- relative position
- energy
- store/d/age
- gravitational interaction
- fall(s/ing)
- electric field
- charged particle(s)
- magnetic field(s)
- magnet
- relative motion
- stored energy
- chemical reaction(s)
- heat
- thermal energy (the motion of atoms or molecules within a substance)
- energy transfer (by convection, conduction, and radiation (particularly infrared and light)
- science

- temperature
- measure
- average kinetic energy
- particles of matter
- total energy of a system
- matter state
- matter amount
- absence of matter

By the end of grade 12.

- energy
- quantitative property
- system
- motion
- interaction(s)
- matter
- radiation
- single quantity
- Conservation of energy (a system's *total* energy energy is conserved)
- energy transformation
- energy on a macroscopic scale
    - motion
    - sound
    - light
    - thermal energy
- mechanical energy (motion + stored energy in an operating machine)
- chemical energy (energy that can be released or stored in chemical processes)
- electrical energy (energy stored in a battery or energy transmitted by electric currents)
- units of energy
- microscopic scale
- can be modeled as either
    - motions of particles
    - energy stored in fields (which mediate interactions between particles).
        - Like radiation
        -

PS3.B: CONSERVATION OF ENERGY AND ENERGY TRANSFER

What is meant by conservation of energy?
How is energy transferred between objects or systems?

- change Δ

- energy
- system
- total energy
- conservation of energy
- energy transfer(s)
- mathematical expressions (which quantify changes in the forms of energy within a system and transfers of energy into or out of the system)
- motion energy (change in shape or temperature of objects)
- macroscopic objects
- collisions
- sliding contact
- energy transfers to the surrounding air (sound or heat)
- energy transfers to molecules (collisions, chemical processes, which increase or decrease the total amount of stored energy within a system of atoms)
- Δ in stored energy
- kinetic energy
- electric current
- heating
- heat transfer
- temperature
- cooling
- conduction
- solid(s)
- liquid(s)
- gas
- convection
- radiation (emitted or absorbed by matter)
- particle in matter
- light
- infrared radiation
- thermal motion of particles in the matter
- wavelength (ultraviolet, X-ray)
- ionization (of atoms or molecules)
- electron
- uncontrolled system(s)
- stable states
- decay
- radioactive isotopes

Grade-Level Endpoints for PS3.B

By the end of grade 2.

- sunlight
- warm
- earth
- surface

By the end of grade 5.

- energy
- object
- sound
- light
- heat
- collide
- energy transfer
- collision
- air
- heat
- light
- energy radiated (as from the sun)
- warm
- Earth
- land
- water
- plant growth
- electric current
- motion
- sound

By the end of grade 8.

- motion energy
- object Δ
- energy
- friction
- thermal energy
- cool
- chemical energy (e.g., burning fuel)
- electrical energy (e.g., an electric motor and a battery)
- temperature

- matter
- nature of the matter
- conduction
- convection
- radiation

By the end of grade 12.

- conservation of energy
- total change of energy
- energy transferred
- energy
- system(s)
- mathematical expressions
- quantify
- stored energy (e.g., relative positions of charged particles, compression of a spring)
- kinetic energy
- mass
- speed
- uncontrolled system(s)
- degrade
- long-lived radioactive isotopes

PS3.C RELATIONSHIP BETWEEN ENERGY AND FORCES

How are forces related to energy?

- object
- interact
- force
- transfer energy
- force fields (gravitational, electric, or magnetic)
- contact forces
- colliding objects
- microscopic level
- electromagnetic force fields
- relative position
- pattern(s) of motion
- force (at each instant)
- force (in terms of transformation of energy between the motion and one or more forms of stored energy)
- elastic collision(s)

- macroscopic scale
- conservation of energy
- microscopic forces

Grade Band Endpoints for PS3.C

By the end of grade 2.

- push
- pull
- fast
- speed
- collision
- Δ in shape

By the end of grade 5.

- object
- collide
- contact force
- transfer energy
- change in an objects' motion
- magnet
- magnetizable material

By the end of grade 8.

- object
- interaction
- force
- energy
- Earth-object system
- gravitational field energy
- gravitational force
- magnetic or electrically charged objects
- transfer energy
- interacting objects.

By the end of grade 12.

- force field(s) (gravitational, electric, and magnetic)
- energy
- space
- Δ in relative position

- motion

PS3.D: ENERGY IN CHEMICAL PROCESSES AND EVERYDAY LIFE

How do food and fuel provide energy?
If energy is conserved, why do people say it is produced or used?

- "producing" energy
- "using" energy
- electricity
- movement
- heat
- objects
- light
- energy
- stored energy
- convenient energy
- resource
- system
- environment
- carbon-based molecules
- photosynthesis
- chemical reaction
- molecule
- oxygen
- electric power generation
- fossil fuels (i.e., coal, oil, and natural gas)
- nuclear fission
- renewable resources (e.g., solar, wind, tidal, geothermal, and hydro power)
- transportation
- alternative fuel (e.g., hydrogen, biofuel)
- economic, social, and environmental costs
- benefits (short and long term)
- technological advances
- regulatory
- energy storage
- system
- friction
- heat energy transfer
- efficiency
- waste materials
- unintended impacts
- environmental impacts

Grade Band Endpoints for PS3.D

By the end of grade 2.

- object
- rub
- friction
- warm

By the end of grade 5.

- produce energy
- conversion
- stored energy
- electricity
- fuel
- "use" energy (e.g., to move around)
- energy transfer to
- heat
- environment
- burn
- fuel
- sun
- chemical process
- plant (Boundary: The fact that plants capture energy from sunlight is introduced at this grade level, but details of photosynthesis are not.)
- concentrate
- battery
- physically transportable energy
- energy storage devices

By the end of grade 8.

- chemical reaction
- plant
- produce
- complex
- food molecules (sugars)
- energy input (i.e., from sunlight)
- carbon dioxide
- water
- carbon-based organic molecules
- oxygen

    - (Boundary: Further details of the photosynthesis process are not taught at this grade level.)
- cellular digestion
- chemical reaction
- machines
- aerodynamic design
- heat

By the end of grade 12.

- nuclear fusion
- sun
- energy
- radiation
- solar energy
- complex chemical process
- photosynthesis
- solar cell
- electrical energy.
- physical process
- chemical process
- living organism
- cell
- transport of energy
- transfer (release or uptake) of energy
- electricity generation
- electricity transportation
- economic, social, and environmental costs
- economic, social, and environmental benefits
- short and long term costs/benefits
- energy conversion to less useful forms—for example, to thermal energy in the surrounding environment
- machines
- efficiency
- waste heat
- environmental impacts