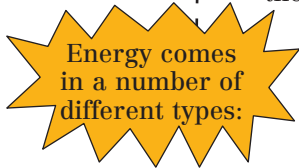



Energy is the ability to make something useful happen.



Whenever something useful happens, energy is transferred.

E.g. Candle  
Chemical energy (in wax)  $\Rightarrow$  Heat  
 $\Rightarrow$  Light } (In flame)

E.g. Electric motor  
Electrical energy  
(in wires)



- Kinetic energy
- Heat energy
- Sound energy (very small  
so probably ignored)

Some transfers are cyclical  
E.g. pendulum

- a. Electric filament light bulb.
- b. Solar cell.
- c. Electric kettle.
- d. Loudspeaker.
- e. Mobile 'phone 'charger'.
- f. Clockwork alarm clock.
- g. Playground swing.
- h. Bungee jumper.
- i. Petrol engine.
- j. Microphone.

4. What provides the energy input for the human body? List all types of energy that the body can transfer the energy input into.

Word	Definition (Longman Dictionary of Contemporary English, 5 <sup>th</sup> Edition)	Farsi Equivalent
<b>Bulb</b>	[countable] the glass part of an electric light, that the light shines from <b>SYN light bulb:</b> <i>a 100-watt bulb</i>	لامپ رشته ای ، بصل النخاع
<b>Bungee Jumping</b>	a sport in which you jump off something very high with a long length of special rope that stretches tied to your legs, so that you go up again without touching the ground	بانجی جامپینگ
<b>Candle</b>	[countable] a stick of wax with a string through the middle, which you burn to give light	شمع
<b>Clockwork</b>	[uncountable] <b>British English</b> clockwork toys, trains, soldiers etc. have machinery inside them that makes them move when you turn a key: <i>mechanical toys powered by clockwork</i> <i>The tape was driven by a clockwork motor.</i>	چرخ های ساعت ، منظم و خودکار
<b>Compress</b>	[intransitive and transitive] to press something or make it smaller so that it takes up less space, or to become smaller: <i>Light silk is best for parachutes, as it compresses well and then expands rapidly.</i>	فشرده کردن ، متراکم کردن
<b>Fuel</b>	[uncountable and countable] a substance such as coal, gas, or oil that can be burned to produce heat or energy: <i>Coal is one of the cheapest fuels.</i>	ماده انرژی زا ، سوخت
<b>Gravitational</b>	[usually before noun] related to or resulting from the force of gravity: <i>the Moon's gravitational field</i> <i>the gravitational pull of the Moon</i>	گرانشی
<b>Ignore</b>	to behave as if you had not heard or seen someone or something: <i>The phone rang, but she ignored it.</i> <i>Sam rudely ignored the question.</i>	نادیده پنداشتن ، صرفنظر کردن
<b>Insignificant</b>	too small or unimportant to be worth consideration.	ناچیز ، بی اهمیت
<b>Kinetic</b>	relating to movement: <i>kinetic energy</i>	جنبشی ، وابسته بحرکت
<b>Loudspeaker</b>	[countable] 1. a piece of equipment used to make sounds louder <i>The voice over the loudspeaker (=using the loudspeaker) said the flight was delayed.</i> 2. a speaker	بلندگو
<b>Measure</b>	an amount or unit in a measuring system: <i>a table of weights and measures</i>	مقیاس ، واحد
<b>Motion</b>	[uncountable] the process of moving or the way that someone or something moves <i>the motion of the planets</i> <i>Newton's first law of motion</i>	جنبش ، تکان ، حرکت ، جنب و جوش
<b>Nuclear</b>	[usually before noun] relating to or involving the nucleus (=central part) of an atom, or the energy produced when the nucleus of an atom is either split or joined with the nucleus of another atom: <i>France's reliance on nuclear energy</i> <i>a nuclear power station</i> <i>a nuclear-powered submarine</i>	هسته ای ، اتمی
<b>Object</b>	[countable] a solid thing that you can hold, touch, or see but that is not alive: <i>an everyday object such as a spoon</i> <i>a small metal object</i> <i>scientists studying plants, animals,</i>	چیز ، مقصود ، شیء ، موضوع

<b>Occur</b>	to happen: <i>A third of accidental deaths occur in the home.</i> <i>The explosion occurred at 5.30 a.m.</i>	رخ دادن ، اتفاق افتادن
<b>Raise</b>	[transitive] to move or lift something to a higher position, place, or level: <i>Can you raise the lamp so I can see?</i> <i>William raised his hat and smiled at her.</i> <i>Raise your hand if you know the right answer.</i>	بالا بردن ، زیاد کردن ، ترقی دادن ، برپا داشتن
<b>Reaction</b>	[uncountable and countable] a) a chemical change that happens when two or more substances are mixed together: <i>a chemical reaction in the soil</i> b) a physical force that is the result of an equally strong physical force in the opposite direction	واکنش ، عکس العمل
<b>Release</b>	to let someone go free, after having kept them somewhere <i>Police arrested several men, who were later released.</i> <i>The bears are eventually released into the wild.</i>	رها و آزاد کردن ، مرخص کردن ، منتشر ساختن
<b>Solar</b>	[only before noun] 1. relating to the sun <b>OPP</b> lunar <i>a solar eclipse</i> 2. using the power of the sun's light and heat: <i>solar energy</i>	وابسته بخورشید ، خورشیدی
<b>Store</b>	to put things away and keep them until you need them	ذخیره کردن ، انبار کردن
<b>Stretch</b>	[intransitive and transitive] to make something bigger or looser by pulling it, or to become bigger or looser as a result of being pulled:	کشیدن ، امتداد دادن ، بسط دادن ، کش آمدن
<b>Surface</b>	[countable] the outside or top layer of something the top layer of an area of water or land <i>Nearly 10% of the Earth's surface is covered by ice</i> <i>The road surfaces tend to be worse in the towns than in the country.</i> <i>a frying pan with a non-stick surface</i>	ظاهر ، سطح
<b>Swing</b>	[countable] a seat hanging from ropes or chains, usually used by children to play on by moving it forwards and backwards using their legs	تاب بازی
<b>Transducer</b>	[countable] a device that converts variations in a physical quantity, such as pressure or brightness, into an electrical signal, or vice versa.	دگرساز ، مبدل
<b>Transfer</b>	[intransitive and transitive] to move from one place, school, job etc. to another, or to make someone do this, especially within the same organization	انتقال دادن ، منتقل کردن
<b>Wax</b>	[uncountable] solid substance made of fat or oil and used to make candles	موم ، مومی شکل
<b>Wire</b>	[countable] a piece of metal like this, used for carrying electrical currents or signals: <i>a telephone wire</i>	سیم ، مفتول

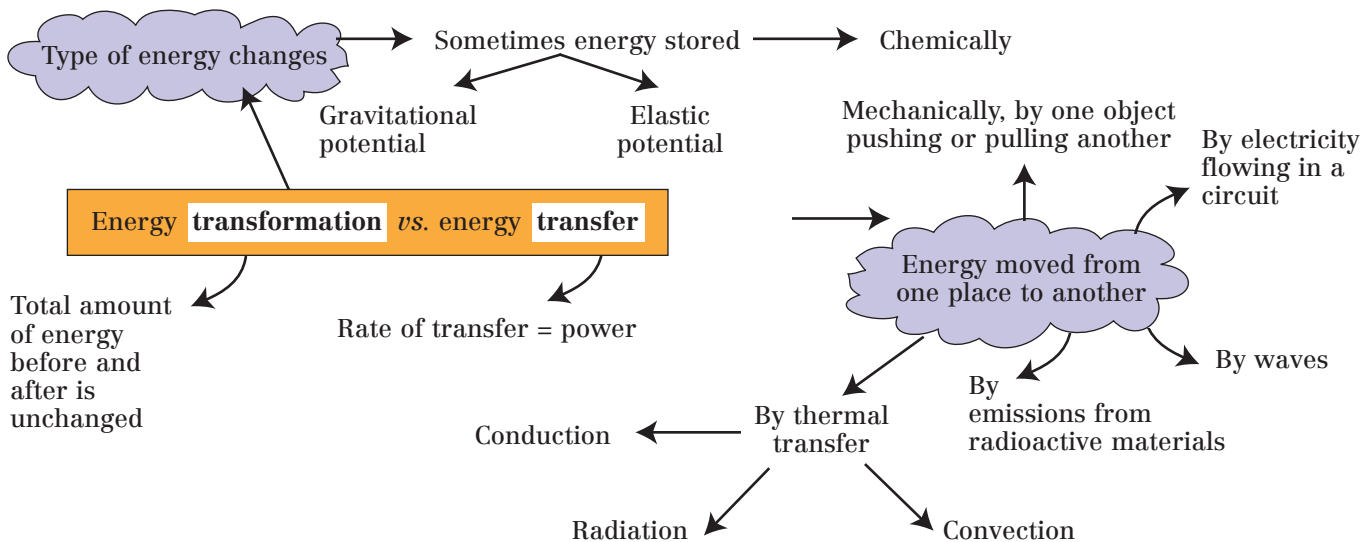
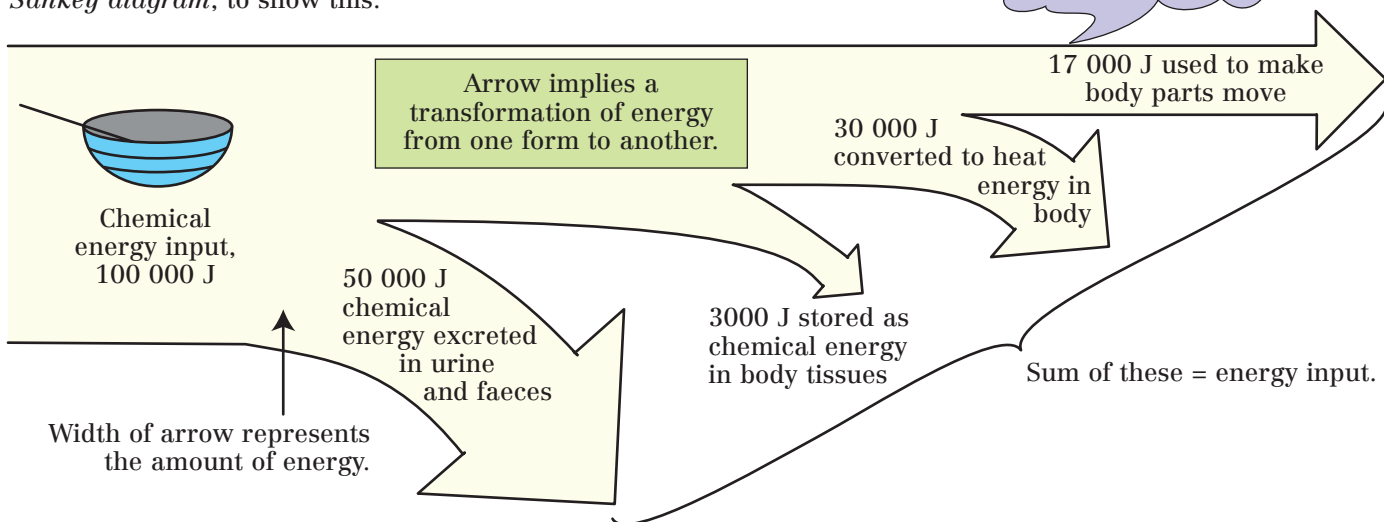
# ENERGY Energy Conservation

Probably the most important idea in Physics is the Principle of Conservation of Energy, which states:

Energy cannot be created or destroyed. It can only be transformed from one form to another form.

This means that the total energy input into a process is the same as the total energy output.

We can use a more sophisticated energy transfer diagram, called a *Sankey diagram*, to show this.



The majority of the rest of this book explores this in more detail.

## Questions

1. State the Principle of Conservation of Energy.
2. What units is energy measured in?
3. Explain the difference between energy transformations and energy transfers. Suggest four ways energy can be transferred.
4. A TV set uses 25 J of energy each second. If 15 J of energy is converted to light and 2 J is converted to sound, how much energy is converted to heat, assuming this is the only other form of energy produced?
5. The motor in a toy train produces 1 J of heat energy and 2 J of kinetic energy every second. What must have been the minimum electrical energy input per second? If the train runs uphill and the electrical energy input stays the same, what would happen to its speed?
6. Use the following data to draw a Sankey diagram for each device:
  - a. Candle (chemical energy in wax becomes heat energy 80% and light 20%).
  - b. Food mixer (electrical energy supplied becomes 50% heat energy in the motor, 40% kinetic energy of the blades, and 10% sound energy).
  - c. Jet aircraft (chemical energy in fuel becomes 10% kinetic energy, 20% gravitational potential energy, and 70% heat).



Word	Definition (Longman Dictionary of Contemporary English, 5 <sup>th</sup> Edition)	Farsi Equivalent
Blade	noun [countable] the flat cutting part of a tool or weapon	تیغہ ، پرہ
Convection	noun [uncountable] technical the movement in a gas or liquid caused by warm gas or liquid rising, and cold gas or liquid sinking	ہمرفت ، فرارفت ، انتقال گرم
Create	verb [transitive] to make something exist that did not exist before: Some people believe the universe was created by a big explosion. Her behaviour is creating a lot of problems. The new factory is expected to create more than 400 new jobs.	خلق شدن ، آفریدن ، ایجاد کردن
Destroy	verb [transitive] to damage something so badly that it no longer exists or cannot be used or repaired ? destruction completely/totally destroy The school was completely destroyed by fire. companies that are polluting and destroying the environment	تخریب کردن ، ویران کردن ، نابود ساختن
Emission	noun 1. [countable usually plural] a gas or other substance that is sent into the air: Britain agreed to cut emissions of nitrogen oxide from power stations. 2. [uncountable] the act of sending out light, heat, gas etc.	تابش ، انتشار امواج ، تشنع امواج
Excrete	verb [intransitive and transitive] formal to get rid of waste material from your body through your bowels, your skin etc.	دفع کردن ، بیرون انداختن ، پس دادن
Faeces	noun [plural] formal (also feces American English) solid waste material from the bowels	مدفوع ، تہ نشست
Gravitational	adjective [usually before noun] related to or resulting from the force of gravity: the Moon's gravitational field the gravitational pull of the Moon	گرانشی
Imply	verb [transitive] past tense and past participle implied, present participle implying, third person singular implies) to suggest that something is true, without saying this directly	دلالت ضمنی کردن ، اشارہ داشتن
Majority	noun (plural majorities) [singular, also + plural verb] most of the people or things in a group OPP minority majority of The majority of workers find it quite hard to live on the amount of money they earn. be in the majority (=form the largest group) In this city, Muslims are in the majority.	اکثریت ، بیشین
Measure	verb [transitive] to find the size, length, or amount of something, using standard units such as inches, metres etc.: The rainfall was measured over a three-month period. measure something in something We can measure the energy that food provides in calories. measuring jug/cup/tape (=one used for measuring)	اندازہ گیری کردن

Principle of Conservation of Energy	Conservation of energy, principle of physics according to which the energy of interacting bodies or particles in a closed system remains constant. From: Encyclopædia Britannica	قانون بقاء انرژی (در هر سیستم بسته، کل میزان انرژی ثابت است.)
Rate	noun [countable] the speed at which something happens over a period of time rate of an attempt to slow down the rate of economic growth at (a) ... rate Children learn at different rates. Our money was running out at an alarming rate. at a rate of something Iceland is getting wider at a rate of about 0.5 cm per year	شدت تغییرات، نواخت، آهنگ تغییرات
Sophisticated	adjective a sophisticated machine, system, method etc. is very well designed and very advanced, and often works in a complicated way: sophisticated software a highly sophisticated weapons system	پیچیده، در سطح بالا
Sum	noun [countable] the sum of something the total produced when you add two or more numbers or amounts together: You will have to pay the sum of the two sets of costs.	مجموع، حاصل جمع
Thermal	adjective [only before noun] 1. relating to or caused by heat: thermal energy 2. thermal clothing is made from special material to keep you warm in very cold weather: thermal underwear	دمایی، گرمایی، حرارتی
Tissue	noun 1. [countable] a piece of soft thin paper, used especially for blowing your nose on: a box of tissues 2. [uncountable] (also tissue paper) light thin paper used for wrapping, packing etc 3. [uncountable] the material forming animal or plant cells	بافت، نسج، دستمال کاغذی
Transfer	verb a) [transitive] to change something into a different form, or to change something so that it can be used for a different purpose or in a different way ? b) [intransitive] to change into a different form, or change into something that can be used for a different purpose or in a different way convert to/into In the process, the light energy converts to heat energy.	تبدیل کردن، برگرداندن
Uphill	adjective towards the top of a hill OPP downhill: an uphill climb	سر بالایی، جاده سربالا
Urine	noun [uncountable] the yellow liquid waste that comes out of the body from the bladder	ادرار، بول

# ENERGY Work Done and Energy Transfer

Whenever something useful happens, energy must be transferred but how can we measure energy?  
The only way to measure energy directly is by considering the idea of *work done*.

$$\text{Work done} = \text{force (N)} \times \text{distance moved in the direction of the force (m)}.$$

The unit of work is therefore the Newto-metre (Nm). This is usually called a Joule, J.

The energy transferred is always equal to the work done by the force.

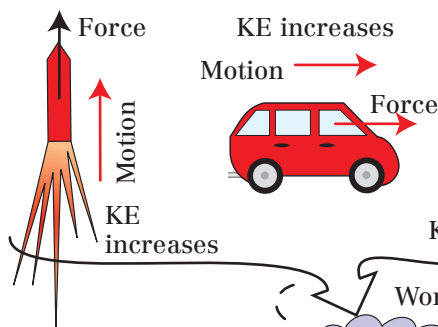
Work done *on* the object.

Object *gains* energy

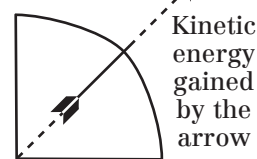
Force and distance in same direction



$$\text{Work done} = +\text{force} \times \text{distance}$$



Bow does work on the arrow



Elastic potential energy lost by the bow

Work done *on* Object 2

Gains energy

Work

Object 1 Loses energy

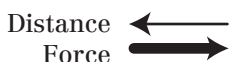
Energy conservation

Elastic potential energy gained by the spring

Gravitational potential energy lost by mass

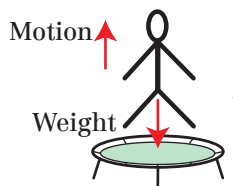
Weight Mass does work on spring

Force and distance are opposite

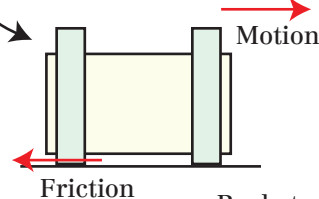


$$\text{Work done} = -\text{force} \times \text{distance}$$

Work done against friction  $\Rightarrow$  decrease in kinetic energy



Work done against gravity  $\Rightarrow$  decrease in kinetic energy



Rocket gains kinetic energy

Fuel loses chemical energy

Fuel does work on the rocket

Golf club loses some kinetic energy

Golf ball gains some kinetic energy

Club does work on the ball

## Questions

1. Copy and complete:

'Work is done when a ? moves an object. It depends on the size of the ? measured in ? and the ? the object moves measured in ?. Whenever work is done, an equal amount of ? is transferred. The unit of energy is the ?. Work is calculated by the formula: work = ?  $\times$  distance moved in the ? of the ?.'

2. I push a heavy box 2 m along a rough floor against a frictional force of 20 N. How much work do I do? Where has the energy come from for me to do this work?

3. A parachute exerts a resistive force of 700 N. If I fall 500 m, how much work does the parachute do?

4. A firework rocket produces a constant thrust of 10 N.

a. The rocket climbs to 150 m high before the fuel is used up. How much work did the chemical energy in the fuel do?

b. Explain why the chemical energy stored in the fuel would need to be much greater than the work calculated in (a).

c. The weight of the empty rocket and stick is 2.5 N. How much work has been done against gravity to reach this height?

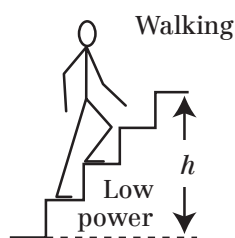
d. The answers to parts (a) and (c) are not the same, explain why.

Word	Definition (Longman Dictionary of Contemporary English, 5 <sup>th</sup> Edition)	Farsi Equivalent
Arrow	noun [countable] a weapon usually made from a thin straight piece of wood with a sharp point at one end, that you shoot with a bow	تیر ، خدنگ ، پیکان
Bow	noun [countable] a weapon used for shooting arrows, made of a long thin piece of wood held in a curve by a tight string: a bow and arrow	کمان ، قوس
Consider	verb [intransitive and transitive] to think about something carefully, especially before making a choice or decision consider whether (to do something) We are considering whether to change our advice to tourists. consider where/how/why etc., We're still considering where to move to.	رسیدگی کردن ، ملاحظه کردن
Distance	noun [uncountable and countable] the amount of space between two places or things distance from/between Measure the distance between the two points. at a distance of 2 feet/10 metres etc. A shark can smell blood at a distance of half a kilometer.	فاصله ، مسافت
Elastic	adjective 1. made of elastic: an elastic cord 2. a material that is elastic can stretch and then go back to its usual length or size: the horny elastic pad in a horse's hoof	الاستیک ، کشسان ، ارتجاعی
Force	noun [uncountable and countable] a natural power or event: the force of gravity powerful natural forces such as earthquakes, floods, and drought	نیرو
Gain	verb [transitive] to increase in weight, speed, height, or value: Carrie's gained a lot of weight recently. The dollar has gained 8% against the ye	افزایش یافتن ، به دست آوردن
Gravitational	adjective [usually before noun] related to or resulting from the force of gravity: the Moon's gravitational field	گرانشی
Increase	verb [intransitive and transitive] if you increase something, or if it increases, it becomes bigger in amount, number, or degree OPP decrease, reduce: The population increased dramatically in the first half of the century. increase (something) from/to something The salary is £18,600 a year, increasing to £23,000.	بزرگتر شدن ، افزایش یافتن ، بالا رفتن
Kinetic	relating to movement: kinetic energy	جنبشی ، وابسته بحرکت
Lose	verb (past tense and past participle lost) [transitive] to stop having a particular attitude, quality, ability etc, or to gradually have less of it I've lost my appetite. lose confidence/interest/hope etc The business community has lost confidence in the government. lose weight/height/speed etc You're looking slim. Have you lost weight?	تلف کردن ، از دست دادن

Mass	noun [uncountable] <b>technical</b> the amount of material in something: The Sun makes up 99.9% of the mass of our solar system.	جرم ، توده
Measure	verb [transitive] to find the size, length, or amount of something, using standard units such as inches, metres etc.: The rainfall was measured over a three-month period. <b>measure something in something</b> We can measure the energy that food provides in calories.	اندازه گیری کردن
Motion	[uncountable] the process of moving or the way that someone or something moves the motion of the planets Newton's first law of motion	جنبش ، تکان ، حرکت ، جنب و جوش
Object	noun [countable] a solid thing that you can hold, touch, or see but that is not alive: an everyday object such as a spoon a small metal object	چیز ، شیء ، موضوع
Parallel	adjective two lines, paths etc. that are parallel to each other are the same distance apart along their whole length: Lines AB and CD are parallel. <b>parallel to</b> She was travelling parallel to her previous route. <b>parallel with</b> The railway is parallel with the canal.	همسو ، موازی
Spring	noun [countable usually plural] something, usually a twisted piece of metal, that will return to its previous shape after it has been pressed down: an old armchair with broken springs	فنر
Thrust	noun [uncountable] <b>technical</b> the force of an engine that makes a car, train, or plane move forward	پیشرانده
Transfer	verb a) [transitive] to change something into a different form, or to change something so that it can be used for a different purpose or in a different way ? b) [intransitive] to change into a different form, or change into something that can be used for a different purpose or in a different way <b>convert to/into</b> In the process, the light energy converts to heat energy.	تبدیل کردن ، برگرداندن
Unit	noun [countable] an amount of something used as a standard of measurement <b>unit of</b> The watt is a unit of electrical power.	یکان ، واحد

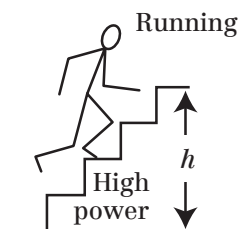


# ENERGY Power



Slow gain in gravitational potential energy.

Low rate of doing work.



Rapid rate of doing work.

Rapid gain in gravitational potential energy.

Power is the number of Joules transferred each second.

The unit of power is the Joule per second, called the Watt, W.

$$\text{Power (W)} = \frac{\text{energy transferred (J)}}{\text{time taken (s)}}$$

Power is the rate of energy conversion between forms.

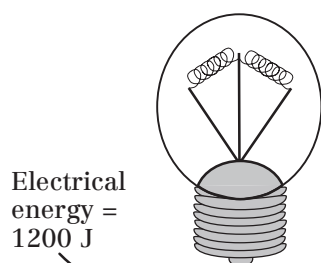
'Rate' means how quickly something happens.

Energy transferred = work done, so

$$\text{Power (W)} = \frac{\text{work done (J)}}{\text{time taken (s)}}$$

Calculating power. Non-mechanical:

- Find out total (heat, light, electrical) energy transferred
- Find out how long the energy transfer took
- Use the formula above

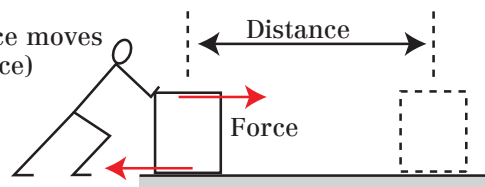


$$\begin{aligned} \text{Power} &= \frac{\text{energy transferred}}{\text{time taken}} \\ &= \frac{1200 \text{ J}}{20 \text{ s}} \\ &= 60 \text{ W} \end{aligned}$$

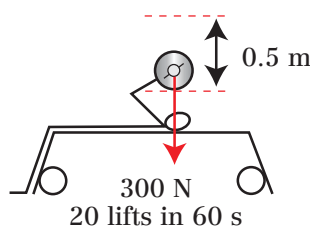
Bulb is switched on for 20 s.

Compare these: imagine how tired you would get if you personally had to do all the work necessary to generate all the electrical power your house uses.

Mechanical:  
(i.e. where a force moves through a distance)



- Calculate the work done = force (N) × distance (m)
- Find out how long the work took to be done
- Use the formula above



$$\begin{aligned} \text{Work done} &= 300 \text{ N} \times 0.5 \text{ m} \\ &= 150 \text{ J per lift} \end{aligned}$$

$$\begin{aligned} \text{Total work done} &= 20 \times 150 \text{ J} \\ &= 3000 \text{ J} \end{aligned}$$

$$\begin{aligned} \text{Power} &= \frac{\text{work done}}{\text{time taken}} = \frac{3000 \text{ J}}{60 \text{ s}} \\ &= 50 \text{ W} \end{aligned}$$

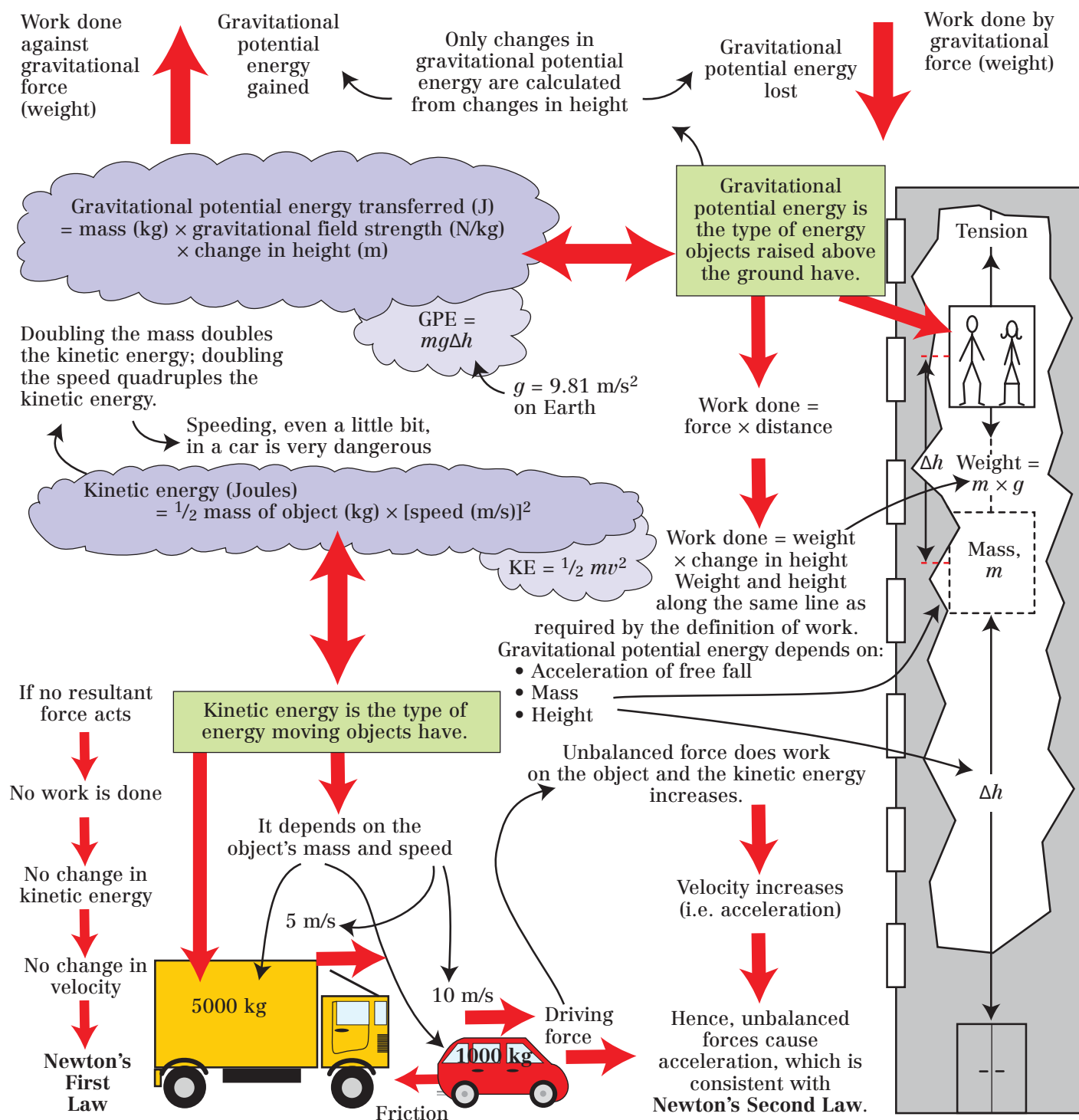
## Questions

1. A kettle converts 62,000 J of electrical energy into heat energy in 50 s. Show its power output is about 1,200 W.
2. A car travels at constant velocity by exerting a force of 1,025 N on the road. It travels 500 m in 17 s. Show that its power output is about 30 kW.
3. The power to three electrical devices is as follows: energy efficient light bulb, 16 W; the equivalent filament bulb, 60 W; a TV on standby, 1.5 W.
  - a. How many more Joules of electrical energy does the filament bulb use in one hour compared to the energy efficient bulb?
  - b. Which uses more energy, a TV on standby for 24 hours or the energy efficient bulb on for 1.5 hours?
4. When I bring my shopping home, I carry two bags, each weighing 50 N up two flights of stairs, each of total vertical height 3.2 m. I have a weight of 700 N.
  - a. How much work do I do on the shopping?
  - b. How much work do I do to raise my body up the two flights of stairs?
  - c. If it takes me 30 s to climb all the stairs, show that my power output is about 170 W.

Word	Definition (Longman Dictionary of Contemporary English, 5 <sup>th</sup> Edition)	Farsi Equivalent
<b>Bow</b>	<i>noun [countable]</i> a weapon used for shooting arrows, made of a long thin piece of wood held in a curve by a tight string: <i>a bow and arrow</i>	کمان ، قوس
<b>Bulb</b>	<i>[countable]</i> the glass part of an electric light, that the light shines from <b>SYN light bulb:</b> <i>a 100-watt bulb</i>	لامپ رشته ای
<b>Calculate</b>	<i>verb [transitive]</i> to find out how much something will cost, how long something will take etc, by using numbers: <i>These instruments calculate distances precisely.</i> <b>calculate how much/how many etc</b> <i>I'm trying to calculate how much paint we need.</i>	حساب کردن ، برآورد کردن
<b>Consider</b>	<i>verb [intransitive and transitive]</i> to think about something carefully, especially before making a choice or decision <b>consider whether (to do something)</b> <i>We are considering whether to change our advice to tourists.</i> <b>consider where/how/why etc.,</b> <i>We're still considering where to move to.</i>	رسیدگی کردن ، ملاحظه کردن
<b>Conversion</b>	<i>noun [uncountable and countable]</i> When you change something from one form, purpose, or system to a different one <b>conversion into</b> <i>The warehouse was undergoing conversion into apartments.</i> <b>conversion of</b> <i>the conversion of waste into usable products</i> <b>conversion to</b> <i>The British conversion to the metric system took place in the 1970s.</i> <b>house/barn/loft etc conversion</b> <i>British English</i> (=when you change the use of a house, barn etc, so that it becomes apartments, a house, a room etc)	تبدیل
<b>Dim</b>	<i>adjective (comparative dimmer, superlative dimmest)</i> fairly dark or not giving much light, so that you cannot see well <b>OPP bright:</b> <i>in the dim light of the early dawn</i> <i>a dim glow</i>	کم نور ، تاریک
<b>Efficient</b>	<i>adjective</i> if someone or something is efficient, they work well without wasting time, money, or energy <b>OPP inefficient:</b> <i>a very efficient secretary</i> <i>an efficient use of land</i> <i>Lighting is now more energy efficient.</i> <b>efficiently</b> <i>adverb</i>	موثر ، کارآمد ، کارا
<b>Imagine</b>	<i>verb [transitive]</i> to form a picture or idea in your mind about what something could be like <b>imagine (that)</b> <i>Imagine that you have just won a million pounds.</i> <i>Imagine life without hot water.</i> <b>imagine what/how/why etc</b> <i>Can you imagine what it's like when it's really hot out here in Delhi?</i>	تصور کردن ، پنداشتن ، فرض کردن ، انگاشتن ، حدس زدن

<b>Kettle</b>	<p><i>noun [countable]</i></p> <p>1. a container with a lid, a handle, and a spout, used for boiling and pouring water <b>SYN teakettle</b> <i>American English:</i>  <i>She filled the kettle and switched it on.</i>  <i>The kettle's boiling (=the water in it is boiling).</i>  <i>Put the kettle on (=start boiling water in a kettle), will you?</i></p> <p>2. <i>American English</i> a large pot, used for making soup</p>	کتری ، آب گرم کن
<b>Necessary</b>	<p><i>adjective</i></p> <p>something that is necessary is what you need to have or need to do, <b>essential:</b>  <i>The booklet provides all the necessary information about the college.</i>  <i>No further changes were considered necessary.</i></p> <p><b>absolutely/really necessary</b>  <i>The police are advising motorists to travel only if their journey is absolutely necessary.</i></p> <p><b>it is necessary (for somebody) to do something</b>  <i>It's not necessary to wear a tie.</i>  <i>The doctor says it may be necessary for me to have an operation.</i></p>	لازم ، واجب ، ضروری
<b>Power</b>	<p><i>noun [uncountable]</i></p> <p>the rate at which energy is used, or the ability to produce energy:  <i>The ship was only slightly damaged in the collision and was able to sail into port under its own power.</i>  <i>The power rating of my amplifier is forty watts per channel.</i></p>	توان ، قدرت
<b>Rapid</b>	<p><i>adjective</i></p> <p>happening or done very quickly and in a very short time <b>SYN fast, quick:</b>  <i>The patient made a rapid recovery.</i></p> <p><b>rapid growth/expansion/development/increase</b>  <i>rapid population growth</i>  <i>a period of rapid decline</i>  <i>He fired three times in rapid succession (=one after another).</i></p>	تندرو ، سریع ، چابک
<b>Rate</b>	<p><i>noun [countable]</i></p> <p>the speed at which something happens over a period of time  <b>rate of</b>  <i>an attempt to slow down the rate of economic growth</i>  <b>at (a) ... rate</b>  <i>Children learn at different rates.</i>  <i>Our money was running out at an alarming rate.</i>  <b>at a rate of something</b>  <i>Iceland is getting wider at a rate of about 0.5 cm per year</i></p>	شدت تغییرات ، نواخت ، اهنگ تغییرات
<b>Unit</b>	<p><i>noun [countable]</i></p> <p>an amount of something used as a standard of measurement  <b>unit of</b>  <i>The watt is a unit of electrical power.</i></p>	یکان ، واحد

# ENERGY Gravitational Potential Energy and Kinetic Energy



## Questions

1. Make a list of five objects that change their gravitational potential energy.
2. Using the diagram above calculate the kinetic energy of the car and the lorry.
3. How fast would the car have to go to have the same kinetic energy as the lorry?
4. The mass of the lift and the passengers in the diagram is 200 kg. Each floor of the building is 5 m high.
  - a. Show that the gravitational potential energy of the lift when on the eighth floor is about 80 000 J.
  - b. How much gravitational potential energy would the lift have when on the third floor? If one passenger of mass 70 kg got out on the third floor, how much work would the motor have to do on the lift to raise it to the sixth floor?
  - c. What is the gravitational potential energy of a 0.5 kg ball 3 m above the surface of the Moon where the gravitational field strength is about 1.6 N/kg?
5. A coin of mass 10 g is dropped from 276 m up the Eiffel tower.
  - a. How much gravitational potential energy would it have to lose before it hits the ground?
  - b. Assuming all the lost gravitational potential energy becomes kinetic energy, how fast would it be moving when it hit the ground?
  - c. In reality, it would be moving a lot slower, why?

Word	Definition (Longman Dictionary of Contemporary English, 5 <sup>th</sup> Edition)	Farsi Equivalent
<b>Consistent</b>	<i>adjective</i> 1. always behaving in the same way or having the same attitudes, standards etc - usually used to show approval <b>OPP inconsistent:</b> <i>She's the team's most consistent player.</i> <b>consistent in</b> <i>We need to be consistent in our approach.</i> 2. continuing to happen or develop in the same way: <i>a consistent improvement in the country's economy</i>	سازگار ، نامتناقض
<b>Definition</b>	<i>noun [countable]</i> a phrase or sentence that says exactly what a word, phrase, or idea means, <i>a dictionary definition</i> <b>definition of</b> <i>There are many definitions of the word 'feminism'.</i> <b>definition of something as something</b> <i>the definition of God as infinite</i>	تعریف ، معنی
<b>Gravitational Potential Energy</b>	<i>noun [countable]</i> energy an object possesses because of its position in a gravitational field. The most common use of gravitational potential energy is for an object near the surface of the Earth where the gravitational acceleration can be assumed to be constant at about 9.8 m/s <sup>2</sup>	انرژی پتانسیل گرانشی
<b>Height</b>	<i>noun</i> 1. <b>HOW TALL [uncountable and countable]</b> how tall someone or something is: <i>Sam's about the same height as his sister now.</i> <i>State your age, height, and weight.</i> <i>buildings of different heights</i> <b>six feet/ten metres etc in height</b> <i>None of these sculptures was less than three metres in height.</i> <b>a height of six feet/ten metres etc</b> <i>Sunflowers can grow to a height of 15 feet.</i> 2. <b>DISTANCE ABOVE THE GROUND [uncountable and countable]</b> the distance something is above the ground: <i>It's a miracle she didn't break her neck falling from that height.</i> <b>a height of 2,500 feet/10,000 metres etc</b> <i>The aircraft was flying at a height of 10,000 metres.</i> <b>gain/lose height</b> (=move higher or lower in the sky) <i>The plane was rapidly losing height.</i>	ارتفاع ، بلندی
<b>Kinetic</b>	<i>adjective technical</i> relating to movement: <i>kinetic energy</i>	جنبشی ، وابسته بحرکت
<b>Lift</b>	<i>noun [countable] British English</i> a machine that you can ride in, that moves up and down between the floors in a tall building <b>SYN elevator American English:</b> <i>They took the lift down to the cafe.</i> <i>It's on the 3rd floor. Let's use the lift.</i>	آسانسور



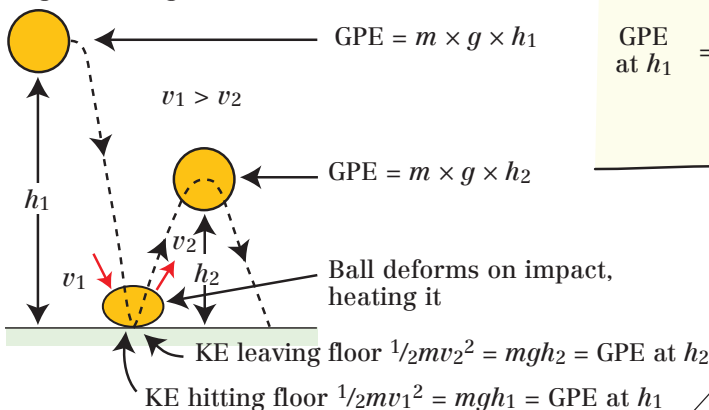
<b>Lorry</b>	<i>noun [countable] British English</i> a large vehicle for carrying heavy goods <b>SYN truck</b>	کامیون ، ماشین باری
<b>Object</b>	<i>noun [countable]</i> a solid thing that you can hold, touch, or see but that is not alive: <i>an everyday object such as a spoon</i> <i>a small metal object</i> <i>scientists studying plants, animals,</i>	چیز ، شیء ، موضوع
<b>Passenger</b>	<i>noun [countable]</i> someone who is travelling in a vehicle, plane, boat etc, but is not driving it or working on it: <i>Neither the driver nor the passengers were hurt.</i> <b>passenger train/plane/ship</b> <i>a crash involving a passenger train</i> <b>bus/rail/airline passengers</b> <i>Rail passengers now face even longer delays.</i>	مسافر
<b>Power</b>	<i>noun [uncountable]</i> the rate at which energy is used, or the ability to produce energy: <i>The ship was only slightly damaged in the collision and was able to sail into port under its own power.</i> <i>The power rating of my amplifier is forty watts per channel.</i>	توان ، قدرت
<b>Rate</b>	<i>noun [countable]</i> the speed at which something happens over a period of time <b>rate of</b> <i>an attempt to slow down the rate of economic growth</i> <b>at (a) ... rate</b> <i>Children learn at different rates.</i> <i>Our money was running out at an alarming rate.</i> <b>at a rate of something</b> <i>Iceland is getting wider at a rate of about 0.5 cm per year.</i>	شدت تغییرات ، نواخت ، اهنگ تغییرات
<b>Speed</b>	<i>noun [uncountable and countable]</i> the rate at which something moves or travels: <i>The truck was travelling at a speed of 50 mph.</i> <i>particles that travel at the speed of light.</i>	تندی (کمیت اسکالر)
<b>Velocity</b>	<i>noun (plural velocities)</i> <i>[uncountable and countable] technical</i> the speed of something that is moving in a particular direction: <i>the velocity of light</i> <i>The speedboat reached a velocity of 120 mph.</i> <i>a high velocity bullet</i>	سرعت (کمیت برداری)
<b>Weight</b>	<i>noun [uncountable and countable]</i> how heavy something is when you measure it: <i>The average weight of a baby at birth is just over seven pounds.</i> <b>in weight</b> <i>fish that are over two kilos in weight</i> <b>by weight</b> <i>Fruit and vegetables are sold by weight.</i>	وزن

# ENERGY Energy Calculations

GPE = gravitational potential energy      KE = kinetic energy

All energy calculations use the *Principle of Conservation of Energy*.

E.g. Bouncing ball



Air resistance is ignored

$$GPE \text{ at } h_1 = KE \text{ at bottom}$$

$$Elastic \text{ potential at bottom} = KE \text{ leaving floor} = GPE \text{ at } h_2$$

Thermal energy in deformed ball

Conservation of energy  
GPE at top of bounce = KE at bottom of bounce  
 $mgh_1 = \frac{1}{2}mv_1^2$   
 $v_1 = \sqrt{2gh_1}$

GPE at top of skydive

Work against friction

KE at bottom

As small as possible to prevent injury

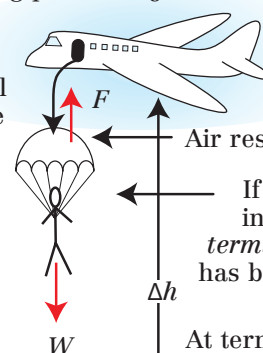
GPE at top is not equal to KE at bottom as some GPE was transferred to work against friction (air resistance).

$$GPE = KE + \text{work against friction}$$

$$mgh_1 = \frac{1}{2}mv^2 + F \times \Delta h$$

$$F = \frac{mgh_1 - \frac{1}{2}mv^2}{\Delta h}$$

GPE on leaving plane =  $mgh_1$

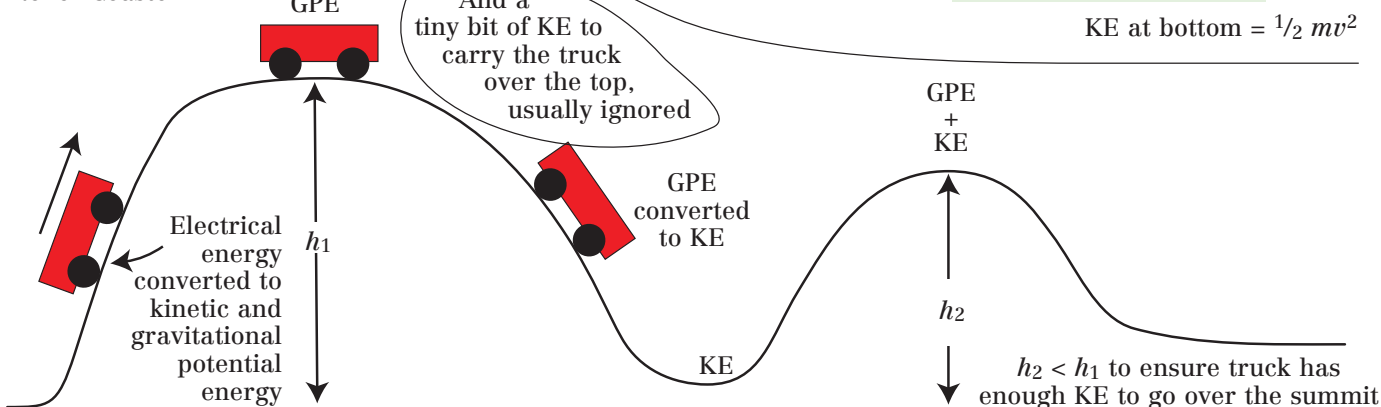


If KE stops increasing, terminal velocity has been reached.

At terminal velocity, all the loss in GPE is doing work against air resistance.

$$KE \text{ at bottom} = \frac{1}{2}mv^2$$

Roller Coaster



Time to reach top of track  
= GPE gain / power of motor =  $mgh_1 / \text{power}$   
The time will be greater than this as some electrical energy is converted to KE and does work against friction.

$$KE \text{ here} = \text{loss of GPE from top}$$

$$\frac{1}{2}mv^2 = mgh_1$$

$$v = \sqrt{2gh_1}$$

This is an overestimate as the truck did work against friction.

**Questions** Take  $g = 9.8 \text{ m/s}^2$ .

- At the start of a squash game, a 44 g ball is struck by a racquet and hits the wall at 10 m/s.
  - Show its KE is about 2 J.
  - The ball rebounds at 8 m/s. Calculate the loss in KE.
  - Where, and into what form, has this energy been transferred?
- An acrobatics aircraft of mass 1000 kg is stationary on a runway. Its take off speed is 150 m/s.
  - Show that the KE of the aircraft at take off is about  $11 \times 10^6 \text{ J}$
- The maximum thrust of the engines is 20 000 N. Show the aircraft travels over 500 m along the runway before it lifts off.
- Give two reasons why the runway will actually need to be considerably longer.
- The aircraft climbs to a height of 1000 m. Show it gains about  $10 \times 10^6 \text{ J}$ .
- If the aircraft takes 5 minutes to reach this height, show the minimum power of the engine must be about 33 kW.
- Why must this be the minimum power?
- The aircraft then flies level at 200 m/s. What is its KE now?
- The pilot cuts the engine and goes into a vertical dive as part of the display. When the plane has dived 500 m what is the maximum KE the plane could have gained?
- Hence, what is the maximum speed the plane could now be travelling at?
- In reality, it will be travelling slower, why?

Word	Definition (Longman Dictionary of Contemporary English, 5 <sup>th</sup> Edition)	Farsi Equivalent
<b>Bounce</b>	<i>noun</i> 1. [countable] the action of moving up and down on a surface: <i>Try to catch the ball on the second bounce.</i> 2. [uncountable] the ability to move up and down on a surface, or that surface's ability to make something move up and down: <i>The ball had completely lost its bounce.</i>	به زمین خوردن و بلند شدن ، جهش الاستیک
<b>Deform</b>	<i>verb [intransitive and transitive]</i> if you deform something, or if it deforms, its usual shape changes so that its usefulness or appearance is spoiled: <i>Wearing badly-fitting shoes can deform your feet.</i>	از شکل انداختن ، تغییر شکل یافتن
<b>Friction</b>	<i>noun [uncountable] technical</i> the natural force that prevents one surface from sliding easily over another surface: <i>Putting oil on both surfaces reduces friction.</i>	سایش ، اصطکاک
<b>GPE (Gravitational Potential Energy)</b>	<i>noun [countable]</i> energy an object possesses because of its position in a gravitational field. The most common use of gravitational potential energy is for an object near the surface of the Earth where the gravitational acceleration can be assumed to be constant at about 9.8 m/s <sup>2</sup>	انرژی پتانسیل گرانشی
<b>Height</b>	<i>noun [uncountable and countable]</i> the distance something is above the ground: <i>It's a miracle she didn't break her neck falling from that height.</i> <b>a height of 2,500 feet/10,000 metres etc</b> <i>The aircraft was flying at a height of 10,000 metres.</i> <b>gain/lose height</b> (=move higher or lower in the sky) <i>The plane was rapidly losing height.</i>	ارتفاع ، بلندی
<b>Impact</b>	<i>noun</i> 1. [countable] the effect or influence that an event, situation etc has on someone or something <b>impact on/upon</b> <i>We need to assess the impact on climate change.</i> <b>major/significant/profound etc impact</b> <i>Higher mortgage rates have already had a major impact on spending.</i> 2. [uncountable and countable] the force of one object hitting another: <i>The force of the impact knocked the breath out of her.</i> 3. <b>on impact</b> at the moment when one thing hits another: <i>The plane's wing was damaged on impact.</i>	ضربه ، برخورد
<b>Injury</b>	<i>noun (plural injuries) [uncountable and countable]</i> a wound or damage to part of your body caused by an accident or attack: <i>She was taken to hospital with serious head injuries.</i> <b>injury to</b> <i>The driver of the truck suffered injuries to his legs and arms.</i> <i>Beckham has missed several games through injury</i> (=because of injury). <i>He's a lawyer who specializes in personal injury claims.</i>	خسارت ، جراحت ، صدمه
<b>Kinetic</b>	<i>adjective technical</i> relating to movement: <i>kinetic energy</i>	جنبشی ، وابسته بحرکت

<b>Overestimate</b>	<p>verb [transitive]</p> <p>1. to think something is better, more important etc than it really is <b>OPP underestimate</b>:  <i>He tends to overestimate his own abilities.</i>  <i>The importance of training in health and safety cannot be overestimated (=is extremely important).</i></p> <p>2. to guess an amount or value that is too high <b>OPP underestimate</b>:  <i>Most patients overestimated how long they had had to wait to see a doctor.</i></p>	<p>زیاد برآورد کردن ، غلو کردن ، دست بالا گرفتن</p>
<b>Principle of Conservation of Energy</b>	<p>Conservation of energy, principle of physics according to which the energy of interacting bodies or particles in a closed system remains constant.  <i>From: Encyclopædia Britannica</i></p>	<p>قانون بقاء انرژی (در هر سیستم بسته، کل میزان انرژی ثابت است).</p>
<b>Resistance</b>	<p>noun</p> <p><b>wind/air/water resistance</b> the way in which wind, air, or water can cause a moving object such as a car, plane, or boat to slow down</p>	<p>ایستادگی ، مقاومت</p>
<b>Terminal Velocity</b>	<p>noun Physics</p> <p>the constant speed that a freely falling object eventually reaches when the resistance of the medium through which it is falling prevents further acceleration</p>	<p>سرعت حد</p>
<b>Track</b>	<p>noun [countable]</p> <p>a) the two metal lines along which trains travel <b>SYN railway line</b>:  <i>The track was damaged in several places.</i>  b) <i>American English</i> the particular track that a train leaves from or arrives at:  <i>The train for Boston is leaving from track 2.</i></p>	<p>خط آهن ، جاده ، راه</p>
<b>Truck</b>	<p>noun [countable]</p> <p>1. a large road vehicle used to carry goods <b>SYN lorry</b> <i>British English</i>:  <i>a truck driver</i>  <b>pick-up/fork-lift/delivery etc truck</b> (=large vehicles used for particular purposes)  <i>His car was taken away on the back of a breakdown truck.</i>  2. <i>British English</i> a railway vehicle that is part of a train and carries goods <b>SYN car</b> <i>American English</i>:  <i>coal trucks</i></p>	<p>کامیون ، واگن روباز</p>
<b>Velocity</b>	<p>noun (plural <b>velocities</b>)</p> <p>[uncountable and countable] <i>technical</i></p> <p>the speed of something that is moving in a particular direction:  <i>the velocity of light</i>  <i>The speedboat reached a velocity of 120 mph.</i>  <i>a high velocity bullet</i></p>	<p>سرعت (کمیت برداری)</p>