AQA P6.1 Energy

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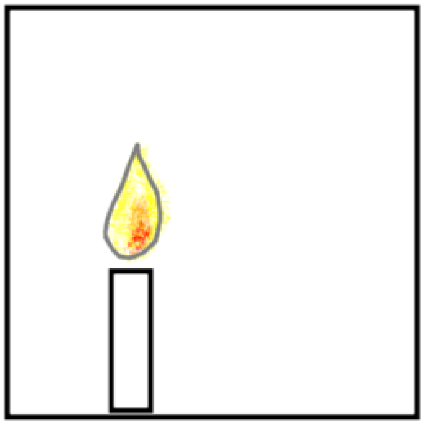
Energy Stores and Systems

A **system** is any object or group of objects that we wish to consider for the purpose of a physics problem. Examples of a system for a physics problem include: a car; a car and its surroundings, the Universe.

There is a quantity in Physics known as **energy**. This quantity has the property of remaining constant in a closed system. That is to say, if we have a system which does not allow energy in or out, the amount of energy in the system will stay the same.

Let us consider an example: Imagine a completely sealed and insulated box. Inside the box is some air and a burning candle. The box is a closed system as no energy can get in or out. The candle burns and eventually goes out. The total amount of energy in the box has not changed. Energy has transferred from one **store** to another.



We can think of energy as being present sometimes as stores and sometimes as pathways.

Stores

We consider energy as a store when it is a property of an object.

Examples of energy stores:

- Kinetic energy store – a property an object has because it is moving
- Potential energy store – a property an object has because it has been lifted
- Chemical energy store – a property an object has because of its chemical composition.
- Elastic potential energy store – a property an object has because it has been stretched or squashed.

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- Thermal energy store – a property an object has because of the kinetic energy of its particles.

Pathways

We can think of energy as a pathway when it is moving between objects.

Examples of energy pathways:

- Light energy pathway
- Electrical energy pathway
- Heating energy pathway

Questions

1. What is a “system”?
2. What is a “closed system”?
3. What happens to the total amount of energy in a closed system?
4. State five examples of energy stores
5. State three examples of energy pathways
6. For the following examples, state the energy store at the start and the energy store at the end:
   a. Switching on a battery powered fan
   b. Burning petrol to drive a car
   c. Burning gas to heat baked beans on a stove

Answers

1. An object or group of objects that we wish to consider for a physics problem
2. A system that does not allow any energy to enter or escape
3. Stays the same
4. Kinetic energy store, gravitational potential energy store, chemical energy store, elastic potential energy store, thermal energy store
5. Electrical energy pathway, light energy pathway, heating energy pathway
6.
   a. Start: chemical energy store End: kinetic energy store
   b. Start: chemical energy store End: kinetic energy store
   c. Start: chemical energy store End: thermal energy store

Intervention Questions

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1. What name is given to “an object or group of objects that we wish to consider for a physics problem”?
2. What name is given to a system that does not allow energy to enter or escape?
3. What happens to the total amount of energy in a closed system?
4. State five examples of energy stores
5. State three examples of energy pathways
6. For the following examples, state the energy store at the start and the energy store at the end:
   a. Switching on a battery powered remote control car
   b. Burning petrol to drive a lorry
   c. Burning gas to heat soup on a stove

Intervention Answers

1. A system
2. A closed system
3. Stays the same
4. Kinetic energy store, gravitational potential energy store, chemical energy store, elastic potential energy store, thermal energy store
5. Electrical energy pathway, light energy pathway, heating energy pathway
   a. Start: chemical energy store   End: kinetic energy store
   b. Start: chemical energy store   End: kinetic energy store
   c. Start: chemical energy store   End: thermal energy store

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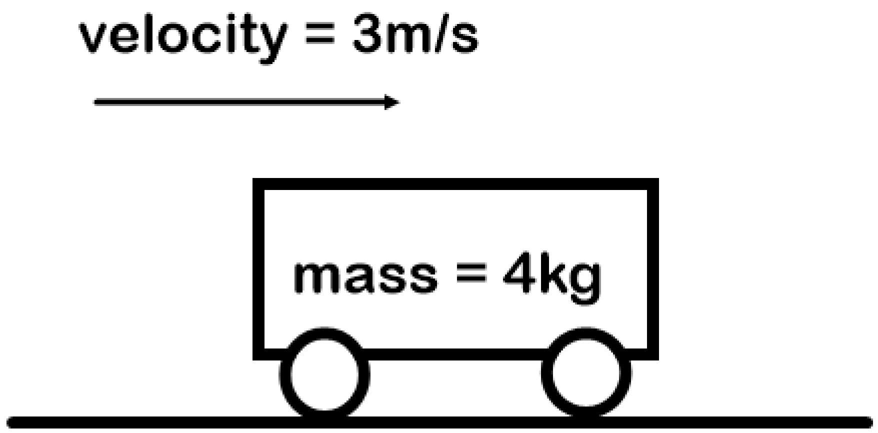
Kinetic energy store

Any object that has mass and is moving has a kinetic energy store. We can calculate kinetic energy store using the formula:

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

where KE = kinetic energy store in J, m = mass in kg and v = velocity in m/s.



You will find it helpful to use "0.5" in your calculator for "½", and to find v^2 before the rest of your calculation, or use the brackets buttons.

Worked examples:

1. Find the kinetic energy store of an object of mass 4kg and velocity 3m/s.

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

KE = 0.5 x 4 x (3^2)
= 0.5 x 4 x 9
= 18J

2. Find the mass of an object with a kinetic energy store of 200J if its velocity is 4m/s.

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

We need to make m the subject:

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

÷ by ½

$$KE \div 0.5 = mv^2$$

↓

$$2KE = mv^2$$

$\div v^2$

$$\frac{2KE}{v^2} = m$$

$$m = \frac{2 \times 200}{4^2}$$

m = 25kg.

3. Calculate the velocity of an object of mass 15kg with a kinetic energy store of 80J.

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We need to make v the subject:

$$KE = \tfrac{1}{2}mv^2$$

÷ by 0.5

$$KE \div 0.5 = mv^2$$

$$2KE = mv^2$$

÷ by m

$$\frac{2KE}{m} = v^2$$

$\sqrt{}$

$$\sqrt{\frac{2KE}{m}} = v$$

$$\sqrt{\frac{2 \times 80}{15}} = 3.27\text{m/s}$$

v = 3.27m/s

Questions:

1. Define kinetic energy store.
2. What is the formula for kinetic energy store?

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3. Why does a train waiting at a station have 0 kinetic energy store?
4. Why does a lorry travelling at 30mph have more KE than a car travelling at the same speed?
5. A ball is moving with a velocity of 5m/s. Its mass is 0.2kg. Calculate its kinetic energy store.
6. A rocket of mass 2800kg travels at 14m/s. What is its kinetic energy store?
7. A cannonball of mass 8.5kg moves at 3389m/s. Find the kinetic energy store of the cannonball.
8. A car of mass 78950kg has a velocity of 287m/s. What is its KE?
9. Find the kinetic energy store of an eagle of mass 0.9kg travelling with a velocity of 18m/s.
10. If a moon of mass 9800kg orbits at a speed of 600m/s, what is its kinetic energy store?
11. Find the kinetic energy store of a plane of mass 5665kg flying at 490m/s.
12. If a trampolinist has KE of 8500J and a mass of 65kg, what speed is he travelling at?
13. A tossed pancake has a mass of 0.05kg and kinetic energy store of 27J. What is the speed of the pancake?
14. A sneezed snot droplet has a mass of 0.006kg. Find its kinetic energy store when it is moving at 14m/s.
15. An alien spacecraft flies past the Earth at 28000m/s. What is its mass given that it has 786500J of kinetic energy store?
16. A bullet of mass 0.012kg has 140J of kinetic energy store. What is its velocity?
17. A motorbike has 657800J of KE and a velocity of 70m/s. What is its mass?
18. Find the velocity of a cyclist with mass 158kg and 4700J of kinetic energy store.

Answers:

1. Energy an object has because it is moving
2. $KE = 1/2mv^2$
3. Because it has 0 velocity
4. Because it has a higher mass
5. 2.5J
6. 274400J
7. 48812614.25J
8. 3251516275J
9. 145.8J
10. 1764000000J
11. 6800083250J
12. 16m/s
13. 32.9m/s
14. 0.588J
15. 0.002kg

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16. 152.8m/s
17. 268.5kg
18. 7.7m/s

Intervention Questions:

1. What do all things with kinetic energy store have in common?
2. What is the formula for kinetic energy store?
3. Why does a light wave have 0 kinetic energy store?
4. Why does an athlete have more KE when sprinting than when running a marathon?
5. A ball is moving with a velocity of 6m/s. Its mass is 0.3kg. Calculate its kinetic energy store.
6. A rocket of mass 45kg travels at 12m/s. What is its kinetic energy store?
7. A cannonball of mass 1.25kg moves at 16m/s. Find the kinetic energy store of the cannonball.
8. A car of mass 180kg has a velocity of 13m/s. What is its KE?
9. Find the kinetic energy store of an eagle of mass 1.1kg travelling with a velocity of 4.5m/s.
10. If a moon of mass 12600kg orbits at a speed of 3.8m/s, what is its kinetic energy store?
11. Find the kinetic energy store of a plane of mass 786kg flying at 3.2m/s.
12. If a trampolinist has KE of 650J and a mass of 48kg, what speed is he travelling at?
13. A tossed pancake has a mass of 0.02kg and kinetic energy store of 4.3J. What is the speed of the pancake?
14. A sneezed snot droplet has a mass of 0.005kg. Find its kinetic energy store when it is moving at 2.1m/s.
15. An alien spacecraft flies past the Earth at 55m/s. What is its mass given that it has 3600J of kinetic energy store?
16. A bullet of mass 0.035kg has 29J of kinetic energy store. What is its velocity?
17. A motorbike has 8000J of KE and a velocity of 4.6m/s. What is its mass?
18. Find the velocity of a cyclist with mass 98kg and 5454J of kinetic energy store.

Intervention Answers

1. They are all moving and all have mass
2. $KE = 1/2mv^2$

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3. Because it has no mass
4. Because they have a higher velocity when sprinting than when marathon running
5. 5.4J
6. 3240J
7. 160J
8. 15210J
9. 11.1375J
10. 90972J
11. 4024.32J
12. 5.20m/s
13. 20.74m/s
14. 0.01J
15. 2.38kg
16. 40.71m/s
17. 756.14kg
18. 10.55m/s

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Elastic potential energy store

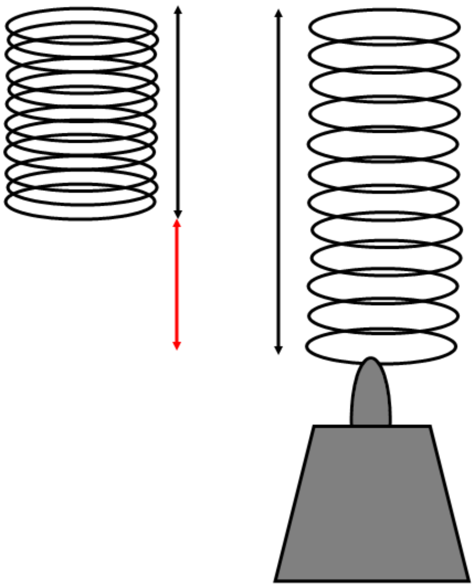
When we stretch an object such as a spring, we give it a store of elastic potential energy. We can calculate it using the equation:

elastic potential energy = 0.5 × spring constant × (extension)^2 $E_e = \frac{1}{2} k e^2$

This formula is on the formula sheet.

The extension of a spring is the extra length it has been stretched – not the total length.

The spring constant tells us how stiff the spring is: A high k means you have to use a lot of energy to stretch the spring.



Questions

1. Define elastic potential energy store
2. When we stretch a spring, what factors affect how much elastic potential energy is stored in it?
3. Do you need to know the total length of the spring to calculate the elastic potential energy store? Why/Why not?
4. Which spring is easier to stretch: A spring with k = 0.5N/m or a spring with k = 40N/m? Why?
5. What does "extension of a spring" measure?
6. What does "spring constant" measure?
7. A spring of spring constant = 2N/m is stretched 3 meters. What is its elastic potential energy store?

8. Helen stretches a spring 6 meters. If its spring constant is 5N/m, how much elastic potential energy does it now store?

9. A spring in a church clock has a spring constant of 12N/m. What is its elastic potential energy store if it is stretched 4.8m?

10. If the extension of a trampoline spring is 0.3m, and its spring constant is 1.8 N/m, how much elastic potential energy store does it store?

11. What is the elastic potential energy store of a spring of spring constant 6.5 N/m when it is stretched 9m?

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12. Ash stretches a spring 11.2m. The spring constant is 3.9 N/m. How much elastic potential energy is stored?
13. Find the elastic potential energy stored in a spring of spring constant 75 N/m if it is extended 40m?
14. Find the extension of a spring of spring constant 12 N/m if the elastic potential energy store stored is 400J.
15. A spring in a car's suspension has elastic potential energy store 36J. If the spring constant is 8 N/m, find the extension.

16. A giant spring has spring constant 400 N/m and elastic potential energy store 96000J. Calculate its extension.
17. Find the spring constant of a spring which stores 1224J of elastic strain energy when extended by 4.4m.
18. What is the spring constant of a spring which has 18J of elastic strain energy when the extension is 1456m?
19. How far must a spring of spring constant 2.5 N/m be extended in order to store 168J of elastic strain energy?

Answers

1. The energy stored in an object (like a spring) because it has been stretched (or squashed)
2. The extension length and the spring constant of the spring
3. No – you just need to know the extension (extra length due to stretching)
4. K = 0.5 N/m as it has a lower spring constant
5. extra length due to stretching
6. How difficult it is to stretch the spring
7. 72J
8. 143.75J
9. 0.054J
10. 12.74J
11. 2450J
12. 131.2J
13. 480000J
14. 8.16m
15. 3m
16. 21.91 N/m
17. 126.45 N/m
18. 0.000016981 N/m
19. 11.59m

Intervention Questions

1. What do all objects with elastic potential energy store have in common?

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2. If you double the extension of a spring, what will happen to the elastic potential energy store stored in it?
3. Ali knows measures the total length of a stretched spring of spring constant = 2 N/m. What other measurement does she need to calculate the elastic potential energy store stored in the spring?
4. Define "extension of a spring"
5. Define "spring constant"
6. A spring of spring constant = 1.5 N/m is stretched 4 meters. What is its elastic potential energy store?
7. Helen stretches a spring 5 meters. If its spring constant is 2 N/m, how much elastic potential energy store does it now have?
8. A spring in a church clock has a spring constant of 15 N/m. What is its elastic potential energy store if it is stretched 2.4m?
9. If the extension of a trampoline spring is 0.7m, and its spring constant is 6.6 N/m, how much elastic potential energy store does it store?
10. What is the elastic potential energy store of a spring of spring constant 28 N/m when it is stretched 7m?
11. Ash stretches a spring 14.8m. The spring constant is 3.9 N/m. How much elastic potential energy store is stored?
12. Find the elastic potential energy store stored in a spring of spring constant 75 N/m if it is extended 4.9m?
13. A spring of length 1.2m is stretched to twice its size. If it stores 84J in elastic strain energy, calculate its spring constant.
14. Find the extension of a spring of spring constant 4 N/m if the elastic potential energy store stored is 3kJ.
15. A spring in a car's suspension has elastic potential energy store 2kJ. If the spring constant is 5 N/m, find the extension.
16. A spring has spring constant 600 N/m and elastic potential energy store 90kJ. Calculate its extension.
17. Find the spring constant of a spring which stores 2.7kJ of elastic strain energy when extended by 0.8km.
18. What is the spring constant of a spring which has 5.5kJ of elastic strain energy when the extension is 100km?
19. How far must a spring of spring constant 38 N/m be extended in order to store 24kJ of elastic strain energy?

Intervention Answers:

1. They have all been stretched or squashed
2. It will quadruple
3. The original length of the spring
4. The extra length it has due to having been stretched
5. How difficult it is to stretch a spring
6. 12 J

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7. 25J
8. 43.2J
9. 1.62J
10. 686J
11. 427.13J
12. 900.38J
13. 116.67
14. 38.73m
15. 28.28m
16. 17.32m
17. 0.0084m
18. 0.0000011 N/m
19. 35.54m

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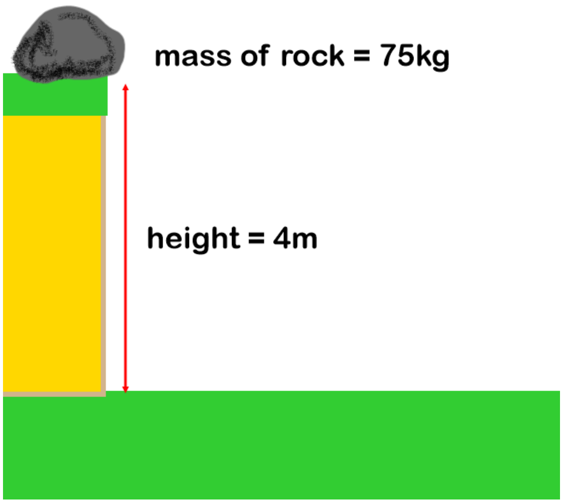
Gravitational potential energy store

Any object with mass that has been raised above the ground stores gravitational potential energy store. You need to be able to remember and apply the formula:

$$GPE = mgh$$



Where GPE = gravitational potential energy store in J

m = mass in kg

g = gravitational field strength in N/kg. This is different for different planets.

h = height above the ground in m.

For example, the diagram shows a rock that has been lifted up. If this happened on Earth where g = 9.8N/kg, the gravitational potential energy store could be calculated by:

GPE = mgh

GPE = 75 x 9.8 x 4 = <u>2940 J</u>

<u>Questions:</u>

1. Define gravitational potential energy store
2. What does g measure?
3. What will happen to GPE if you double the height of an object?
4. Find the gravitational potential energy store of an apple of mass 0.23kg, 65m above the Earth's surface. Assume g is 9.8 N/kg.
5. A cable car of mass 4,500kg is suspended 120m above the Earth's surface. Find the gravitational potential energy store of the cable car. Assume g = 9.8 N/kg.
6. An astronaut lifts a golf ball 2.6m above the Moon's surface. If the golf ball's mass is 0.02kg, find its gravitational potential energy store. Assume g = 1.63 N/kg.
7. A spaceship of mass 9,950kg lands at the top of a mountain 5005m above Jupiter's surface. Acceleration due to gravity on Jupiter is 24.5 N/kg. Find the GPE of the spaceship
8. An aeroplane flies over Venezuela at a height of 6,800m. If its mass is 3,500kg, find its gravitational potential energy store.

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9. A helicopter hovers 568m above a field and has 96,000J of gravitational potential energy store. Assuming *g* = 9.8N/kg, find the helicopter's mass.
10. What is the mass of a rocket 5,000m above the Moon's surface if it has 84,000J of gravitational potential energy store? Assume *g* on the Moon = 1.63N/kg.
11. A buzzard is flying 98m above the Earth's surface. Assuming *g* = 9.8N/kg, what is the mass of the buzzard if its gravitational potential energy store is 5,403J?
12. Find the mass of a peach with gravitational potential energy store 1.2J if it is hanging on a tree 3m above the Earth's surface. Assume *g* = 9.8N/kg.
13. A blimp is travelling above the surface of Jupiter at a height of 3,905m. Assuming *g* on Jupiter is 24.5N/kg, find the mass of the blimp if its gravitational potential energy store is 280,060J.
14. A helicopter of mass 6500kg has gravitational potential energy store 48,900J. Find its height above the Earth's surface. Assume *g* = 9.8N/kg.
15. Find the height of an osprey of mass 2.6kg flying above the Earth's surface if its gravitational potential energy store is 5,643J. Assume g= 9.8N/kg.
16. What height must we raise a block of mass 57kg above the surface of the Moon in order to give it 2,445J of gravitational potential energy store. Assume *g* on the Moon is 1.63N/kg.
17. A mosquito has mass 0.004kg and gravitational potential energy store 80,075J. Find its height above the Earth's surface. Take *g* as 9.8N/kg.
18. A space probe has 5,008J of gravitational potential energy store and a mass of 78kg. Find its height above Jupiter's surface. Assume *g* = 24.5N/kg

Answers:

1. Energy an object has because it has been raised above the surface of a planet (or other celestial body)
2. Acceleration due to gravity
3. It will double
4. 146.51J
5. 5292000J
6. 0.085J
7. 1220093875J
8. 233240000J

9. 17.25kg
10. 10.31kg
11. 5.63kg
12. 0.04kg
13. 2.93kg

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14. 0.77m
15. 221.47m
16. 26.32m
17. 2042729.59m
18. 2.6m

Intervention Questions:

1. Explain what "gravitational potential energy store" means.
2. What does *g* stand for?
3. What will happen to GPE if you half the height of an object?

4. Find the gravitational potential energy store of an apple of mass 1.23kg, 45m above the Earth's surface. Assume *g* is 9.8 N/kg.
5. A cable car of mass 3,500kg is suspended 220m above the Earth's surface. Find the gravitational potential energy store of the cable car. Assume *g* = 9.8 N/kg.
6. An astronaut lifts a golf ball 9.6m above the Moon's surface. If the golf ball's mass is 0.04kg, find its gravitational potential energy store. Assume *g* = 1.63 N/kg.
7. A spaceship of mass 8,850kg lands at the top of a mountain 504m above Jupiter's surface. Acceleration due to gravity on Jupiter is 24.5 N/kg. Find the GPE of the spaceship
8. An aeroplane flies over Venezuela at a height of 4,500m. If its mass is 350kg, find its gravitational potential energy store.

9. A helicopter hovers 86m above a field and has 6,600J of gravitational potential energy store. Assuming *g* = 9.8N/kg, find the helicopter's mass.
10. What is the mass of a rocket 5000m above the Moon's surface if it has 94,000J of gravitational potential energy store? Assume *g* on the Moon = 1.63N/kg.
11. A buzzard is flying 98m above the Earth's surface. Assuming *g* = 9.8N/kg, what is the mass of the buzzard if its gravitational potential energy store is 7,403J?
12. Find the mass of a peach with gravitational potential energy store 3.2J if it is hanging on a tree 3m above the Earth's surface. Assume *g* = 9.8N/kg.
13. A blimp is travelling above the surface of Jupiter at a height of 4,905m. Assuming *g* on Jupiter is 24.5N/kg, find the mass of the blimp if its gravitational potential energy store is 680,060J.
14. A helicopter of mass 6500kg has gravitational potential energy store 48900J. Find its height above the Earth's surface. Assume *g* = 9.8N/kg.
15. Find the height of an osprey of mass 2.6kg flying above the Earth's surface if its gravitational potential energy store is 5643J. Assume g= 9.8N/kg.

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16. What height must we raise a block of mass 57kg above the surface of the Moon in order to give it 2445J of gravitational potential energy store. Assume *g* on the Moon is 1.63N/kg.
17. A mosquito has mass 0.004kg and gravitational potential energy store 80075J. Find its height above the Earth's surface. Take *g* as 9.8N/kg.
18. A space probe has 5008J of gravitational potential energy store and a mass of 78kg. Find its height above Jupiter's surface. Assume *g* = 24.5N/kg

Intervention Answers:

1. Energy an object has because it has been raised up high
2. Gravitational field strength
3. It will half

4. 542.43J
5. 7,546,000J
6. 3.69J
7. 109,279,800J
8. 15,435,000J

9. 7.83kg
10. 11.53kg
11. 7.71kg
12. 0.11kg
13. 5.66kg
14. 0.77m
15. 221.47m
16. 26.32m
17. 2042729.59m
18. 2.62m

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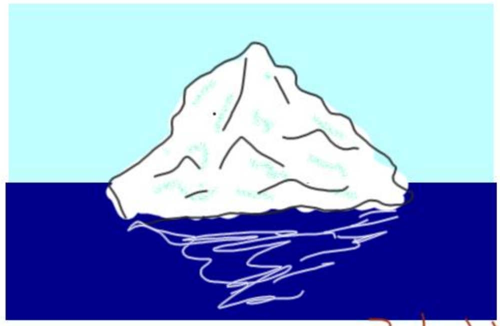
Specific Heat Capacity

Which has more heat energy: an iceberg or a steaming cup of tea?



The iceberg actually has more heat energy. This is because heat energy is the total kinetic energy store of all the particles in a system. Temperature is the average kinetic energy store of the particles in a system. So the cup of tea has a higher temperature as its particles are moving faster, but because it has so few particles compared to the iceberg, the total KE is lower.

Different materials have different relationships between heat energy and temperature. This relationship is called their specific heat capacity. It is given by the formula:

change in thermal energy = mass × specific heat capacity × temperature change	$\Delta E = m\,c\,\Delta\theta$

Which is given on your formula sheet.

Consider two blocks of metal of equal mass:

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Copper

Specific heat capacity = 386J/kg°C

Gold

Specific heat capacity = 126 J/kg°C

If we add the same amount of heat energy to each block, they will respond in different ways. If we add 500J of heat energy to each, for example,

Change in thermal energy = 500J

Change in thermal energy = 500J

The temperature increase will be higher for the gold than for the copper. It takes the gold less energy to increase its temperature by 1°C (126J) than it takes copper to do the same (386J).

Change in temp = 1.30°C

Change in temp = 3.97°C

So gold is "easier to heat up" because it has a lower specific heat capacity. In other words, it takes less energy (126J) to raise the temp of 1kg of gold by 1°C.

This leads us to the definition of specific heat capacity:
The specific heat capacity of a substance is the amount of energy required to raise the temperature of one kilogram of the substance by one degree Celsius.

Another way of looking at the example above is: If you wanted to raise the temperature of both blocks by the same amount, you would have to add roughly 3 times as much heat energy to the copper block as to the gold one.

If we look at the term "specific heat capacity" we can think about its meaning:

"Specific" means unique to that substance: e.g. gold has its own SHC, so does water, so does granite, etc.

"Heat" means thermal energy.

"Capacity" means internal space for something.

So together these words mean something like "how much space is there inside 1kg of this particular material for heat energy before it

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shows itself as a rise in temperature”. If there is lots of space then the temperature won’t rise much when you add heat energy.

Questions:

1. Define specific heat capacity.
2. What does it mean if a substance A has a higher specific heat capacity than substance B?
3. What is the difference between heat and temperature?
4. Consider 4kg of copper and 4kg of gold, both at 50°C. Which one contains the most heat energy?

5. Find the change in thermal energy for 3.4kg of bismuth if its temperature is raised by 14°C. The specific heat capacity of bismuth is 123J/kg°C.
6. A block of silver of mass 12.5kg is heated to raise its temperature by 37°C. Find the thermal energy required. The specific heat capacity of silver is 233J/kg°C.
7. A tungsten wire of mass 0.04kg experiences an increase in temperature of 260°C. Find the thermal energy increase. The specific heat capacity of tungsten is 134J/kg°C.
8. A refrigeration unit cools water of mass 14.8kg by 19°C. Find the thermal energy removed from the water. The specific heat capacity of water is 4186J/kg°C.
9. A block of granite of mass 368kg is heated from 22°C to 45°C. Find the energy transferred to the block. The specific heat capacity of granite is 790J/kg°C.
10. To heat the water in a tank from 50°C to 58°C an immersion heater transfers 4032 kJ of energy to the water. Calculate the mass of water in the tank. The specific heat capacity of water = 4200 J/kg°C

11. A block of glass is heated to increase its temperature by 19°C. 15800J of energy is transferred to the block. Find the mass of the block. The specific heat capacity of glass is 840J/kg°C.

12. A heated copper pan loses 5785J of energy to the surroundings when it cools from 150°C to 30°C. The specific heat capacity of copper is 386J/kg°C. Find the mass of the pan.

13. Find the mass of a brass object which gains 387J of energy when its temperature is increased by 1.4°C. The specific heat capacity of brass is 380J/kg°C.

14. Find the mass of zinc needed to absorb 2300J of energy if it is heated from 50°C to 61°C. Zinc has a specific heat capacity of 387J/kg°C

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15. A mass of 3.4kg of water gains 6800J of energy. The specific heat capacity of water is 4186J/kg°C. Find the temperature change.

16. Lead has a specific heat capacity of 128 J/kg°C. Find the temperature change if a mass of 6.2kg of lead has 4500J of thermal energy added to it.

17. Zinc has a specific heat capacity of 387J/kg°C. A student uses a Bunsen flame to add 2980J of energy to a 0.5kg piece of zinc. Calculate the temperature change.

18. A student has a mass of 3.6kg of mercury. She adds 450J of thermal energy to it. Mercury has a specific heat capacity of 140J/kg°C. By how much does the temperature of the mercury increase?

19. 14kg of alcohol is heated in a tank. It gains 8765J of thermal energy. If the specific heat capacity of alcohol is 2400J/kg°C, what is the temperature change in the alcohol?

20. A student has 3kg of copper at 25°C. She adds 7654J of thermal energy. Find the final temperature of the copper. The specific heat capacity of copper is 386J/kg°C.

21. A heated block of silver is cooled to 4°C. It loses 5645J of thermal energy. If the mass of the block is 0.9kg, find the starting temperature of the block. The specific heat capacity of silver is 233J/kg°C.

22. A teacher takes a piece of gold of mass 0.08kg and heats it to reach 450°C. The gold gained 6700J of thermal energy. Find the starting temperature of the gold. The specific heat capacity of gold is 126 J/kg°C.

23. The specific heat capacity of water is 4186J/kg°C. 67kg of water is given 5430J of energy. If the starting temperature of the water was 20.0°C, find the end temperature of the water.

24. The specific heat capacity of granite is 790J/kg°C. If a block of granite of mass 4.6kg is given 7650J of thermal energy and the starting temperature was 15°C, find the end temperature of the block.

Answers

1. The amount of energy needed to raise the temperature of 1kg of a material by 1°C.
2. It will take more heat energy to raise the temp of 1kg of substance A by 1°C than it will for substance B

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3. Heat is the total KE of all the particles in the system; temperature is the average KE of all the particles in the system.
4. Copper
5. 5854.8J
6. 107762.5J
7. 1393.6
8. 1177103.2J
9. 7013620J
10. 0.12kg
11. 0.99kg
12. 0.13kg
13. 0.54kg
14. 0.54kg
15. 0.48°C
16. 5.67°C
17. 15.40°C
18. 0.89°C
19. 0.26°C
20. 31.61°C
21. 30.92°C
22. -214.68°C
23. 20.02°C
24. 17.11°C

Intervention Questions:

1. A student says: Different specific heat capacities are like the fact that some people have to eat loads of food to put on weight, while others eat just a little bit of food and put on a lot of weight. Explain what he means.
2. What does it mean if a substance A has double the specific heat capacity of substance B?
3. Why is it true that an iceberg contains more heat energy than a steaming cup of tea?

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4. Consider 4kg of copper and 4kg of gold, both at 50°C. Which one contains the least heat energy?

5. Find the change in thermal energy for 4.4kg of bismuth if its temperature is raised by 15°C. The specific heat capacity of bismuth is 123J/kg°C.
6. A block of silver of mass 13.5kg is heated to raise its temperature by 47°C. Find the thermal energy required. The specific heat capacity of silver is 233J/kg°C.
7. A tungsten wire of mass 0.08kg experiences an increase in temperature of 160°C. Find the thermal energy increase. The specific heat capacity of tungsten is 134J/kg°C.
8. A refrigeration unit cools water of mass 12.8kg by 11°C. Find the thermal energy removed from the water. The specific heat capacity of water is 4186J/kg°C.
9. A block of granite of mass 168kg is heated from 32°C to 45°C. Find the energy transferred to the block. The specific heat capacity of granite is 790J/kg°C.
10. To heat the water in a tank from 40°C to 58°C an immersion heater transfers 5032 kJ of energy to the water. Calculate the mass of water in the tank. The specific heat capacity of water = 4200 J/kg°C

11. A block of glass is heated to increase its temperature by 29°C. 15804J of energy is transferred to the block. Find the mass of the block. The specific heat capacity of glass is 840J/kg°C.

12. A heated copper pan loses 6785J of energy to the surroundings when it cools from 140°C to 30°C. The specific heat capacity of copper is 386J/kg°C. Find the mass of the pan.

13. Find the mass of a brass object which gains 3587J of energy when its temperature is increased by 2.4°C. The specific heat capacity of brass is 380J/kg°C.

14. Find the mass of zinc needed to absorb 4300J of energy if it is heated from 52°C to 61°C. Zinc has a specific heat capacity of 387J/kg°C

15. A mass of 6.4kg of water gains 6850J of energy. The specific heat capacity of water is 4186J/kg°C. Find the temperature change.

16. Lead has a specific heat capacity of 128 J/kg°C. Find the temperature change if a mass of 6.1kg of lead has 4502J of thermal energy added to it.

17. Zinc has a specific heat capacity of 387J/kg°C. A student uses a Bunsen flame to add 2988J of energy to a 0.6kg piece of zinc. Calculate the temperature change.

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18. A student has a mass of 1.6kg of mercury. She adds 4506J of thermal energy to it. Mercury has a specific heat capacity of 140J/kg°C. By how much does the temperature of the mercury increase?

19. 1.4kg of alcohol is heated in a tank. It gains 9765J of thermal energy. If the specific heat capacity of alcohol is 2400J/kg°C, what is the temperature change in the alcohol?

20. A student has 1.3kg of copper at 15°C. She adds 7654J of thermal energy. Find the final temperature of the copper. The specific heat capacity of copper is 386J/kg°C.

21. A heated block of silver is cooled to 14°C. It loses 5645J of thermal energy. If the mass of the block is 0.8kg, find the starting temperature of the block. The specific heat capacity of silver is 233J/kg°C.

22. A teacher takes a piece of gold of mass 0.04kg and heats it to reach 460°C. The gold gained 670J of thermal energy. Find the starting temperature of the gold. The specific heat capacity of gold is 126 J/kg°C.

23. The specific heat capacity of water is 4186J/kg°C. 6.7kg of water is given 5430J of energy. If the starting temperature of the water was 10.0°C, find the end temperature of the water.

24. The specific heat capacity of granite is 790J/kg°C. If a block of granite of mass 4.1kg is given 7654J of thermal energy and the starting temperature was 16°C, find the end temperature of the block.

Intervention Answers

1. The food is like heat energy and putting on weight is like temperature change. Substances with a high specific heat capacity have to have a lot of heat energy (eat a lot of food) to raise the temperature by 1°C (put on weight).
2. It takes twice as much heat energy to raise the temp of 1kg of substance A by 1°C than it does for substance B.
3. Heat is the total KE of all particles in a system and an iceberg has many more particles
4. Gold

5. 8118J

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6. 147838.5J
7. 1715.2J
8. 589388.8J
9. 1725360J
10. 0.07kg
11. 0.65kg
12. 0.16kg
13. 3.93kg
14. 1.23kg
15. 0.26°C
16. 5.77°C
17. 12.87°C
18. 20.12°C
19. 2.91°C
20. 30.25°C
21. 44.28°C
22. 327.06°C
23. 10.19°C
24. 18.36°C

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Power

Power is defined as

“The rate at which energy is transferred” or “The rate at which work is done”

(Work done is just another term for energy transferred.)

In other words, a more powerful device transfers more energy every second.

There are several formulae you need to remember and apply:

$$\text{power} = \frac{\text{energy transferred}}{\text{time}}$$

$$\left[P = \frac{E}{t}\right]$$

$$\text{power} = \frac{\text{work done}}{\text{time}}$$

$$\left[P = \frac{W}{t}\right]$$

These are just two versions of the same thing.

The unit of power is Watts (W). 1 Watt = 1 Joule per second.

Questions

1. Define “power”.
2. Define 1 Watt.
3. What are the two equations for power?
4. An athlete trains by running up some stairs. Describe 3 ways she could increase the power of this exercise.
5. Why does a more powerful engine give a higher speed?
6. Why can a more powerful electric motor lift a mass more quickly?

7. An electric motor transfers 8 J of energy in 2.5 seconds. Calculate its power.
8. A car transfers 5950J of energy in 35 seconds. Find the power of the car.
9. A weightlifter gives a dumbbell 8900J of gravitational potential energy store in 1.2 seconds. What is the weightlifter’s power?

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10. Find the power of a lift that transfers 486J of energy in 36 seconds
11. What is the power of an engine that does 9700J of work in 11 seconds?

12. A student investigates an immersion heater of power 35W. Calculate the work done by the immersion heater if it is left on for 700 s.
13. Calculate the time the heater was on for, if it transferred 18500J of energy to the system.
14. A lorry contains an engine with a power of 42,000W. The lorry drives for 15 seconds. Calculate the energy transferred.
15. How long will it take for the lorry to transfer 850J of energy?
16. Find the work done by an electric motor of power = 125W if it is switched on for 80s.
17. How long will it take this motor to transfer 180J of energy?
18. How much energy can be transferred by a motor of power 54W in 38 seconds?
19. Calculate the work done on a cart pulled by a tractor of power 8,050W in 400 seconds
20. A tow-truck of power 35,870W pulls a broken-down car for 340s. What energy is transferred?
21. A horse uses 18,750J of energy to pull a plough. If the power of the horse is 5,463W, find the time the plough was pulled.

Extension

1. How long will it take an electric motor of power 24W to lift 1.5kg 3.6m? Assume gravitational field strength is 9.8N/kg.
2. A motorcycle has a worn-out engine with a power of 1800W. It takes 12 seconds to accelerate from rest to 15m/s. A mechanic replaces the engine with a similar one of 3600W. What will happen to the time the motorcycle takes to accelerate from 0-15m/s?
3. A crane has a motor of power 150kW. Find the maximum mass the crane can lift 40m in 30 seconds. Assume gravitational field strength is 9.8N/kg.
4. How far can a motor of power 2.5kW pull a weight of 39N in 100s? Assume no energy is needed to overcome friction.
5. A student has two different electric motors and would like to compare their power. Suggest an experiment to compare their power.

Answers

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1. The rate of energy transfer or the rate of work done
2. 1 Joule per second
3. Power = energy / time   Power = work done / time
4. 1) do the same exercise in a shorter time 2) Increase the work done by carrying extra weight 3) Increase the work done by going up more stairs in the same time.
5. More energy is transferred per second. (and KE = $1/2mv^2$)
6. More energy is transferred per second (and GPE = mgh)

7. 3.2W
8. 170W
9. 7416.67W
10. 13.5W
11. 881.82W

12. 24500J
13. 528.57s
14. 630,000J
15. 49.41s
16. 10,000J
17. 1.44s
18. 2052J
19. 3,220,000J
20. 12195800J
21. 3.43s

Extension

1. 2.21s
2. It will half
3. 11,479.59kg
4. 6,410.26m
5. The student should set up the motors to lift two masses of known weight and time how long each takes to reach a certain height. Work done can then be calculated as GPE = mgh which is equivalent to Wd = fd. The energy can be divided by the time taken for each motor to find its power.

Intervention Questions

1. What does it mean if engine A is more powerful than engine B?
2. Define "5 Watts"

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3. Draw two formula triangles for power
4. A weightlifter lifts a dumbbell to waist height with a power of 50W. What 3 things could he change to increase the power of his lift?
5. Why does a less powerful engine give a lower speed?
6. Why can a less powerful electric motor lift a mass less quickly?

7. An electric motor transfers 20J of energy in 3.5 seconds. Calculate its power.
8. A car transfers 400J of energy in 45 seconds. Find the power of the car.
9. A weightlifter gives a dumbbell 55,000J of gravitational potential energy store in 1.8 seconds. What is the weightlifter's power?
10. Find the power of a lift that transfers 3070J of energy in 46 seconds
11. What is the power of an engine that does 9750J of work in 21 seconds?

12. A student investigates an immersion heater of power 65W. Calculate the work done by the immersion heater if it is left on for 400 s.
13. Calculate the time the heater was on for, if it transferred 26500J of energy to the system.
14. A lorry contains an engine with a power of 54,000W. The lorry drives for 16 seconds. Calculate the energy transferred.
15. How long will it take for the lorry to transfer 98,000J of energy?
16. Find the work done by an electric motor of power = 238W if it is switched on for 40s.
17. How long will it take this motor to transfer 440J of energy?
18. How much energy can be transferred by a motor of power 32W in 46 seconds?
19. Calculate the work done on a cart pulled by a tractor of power 4,050W in 300 seconds
20. A tow-truck of power 25,870W pulls a broken-down car for 240s. What energy is transferred?
21. A horse uses 28,750J of energy to pull a plough. If the power of the horse is 463W, find the time the plough was pulled.

Extension

1. How long will it take an electric motor of power 34W to lift 1.5kg 2.6m? Assume gravitational field strength is 9.8N/kg.
2. A motorcycle has a worn-out engine with a power of 1800W. It takes 12 seconds to accelerate from rest to 15m/s. A mechanic

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replaces the engine with a similar one of 900W. What will happen to the time the motorcycle takes to accelerate from 0-15m/s?
3. A crane has a motor of power 50kW. Find the maximum mass the crane can lift 400m in 30 seconds. Assume gravitational field strength is 9.8N/kg.
4. How far can a motor of power 2.5kW pull a weight of 560N in 100s? Assume no energy is needed to overcome friction.

Intervention Answers

1. Engine A transfers energy more quickly than B
2. 5 Joules transferred every second
3. 

4. 1) do the same lift in a shorter time 2) increase work done by lifting it higher 3) increase work done by lifting a heavier weight
5. Less energy transferred per second and KE = $1/2mv^2$
6. Less energy transferred per second and GPE = mgh

7. 5.71W
8. 8.89W
9. 30,555.56W
10. 66.74W
11. 464.29W

12. 26,000J
13. 407.69s
14. 864,000J
15. 1.81s
16. 9520J
17. 0.54s
18. 1472J
19. 1,215,000J
20. 6,208,800J
21. 62.10s

Extension

1. 1.12s
2. It will half
3. 4.17kg
4. 446.43m

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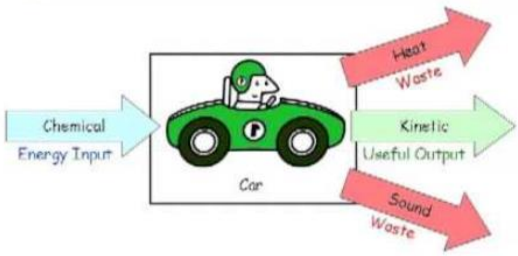
Dissipation

Whenever energy is transferred, some of the input energy is wasted as less useful energy. We call this "dissipation". Dissipated energy spreads out into the surroundings and cannot be used again.

Here are some examples:



Car: Energy is dissipated as heat and sound

Torch: Energy is dissipated as heat

Bouncing ball: Energy is dissipated as heat

Motor: Energy is dissipated as heat and sound.

Questions:

1. Define "dissipation"
2. What forms does dissipation of energy usually take?
3. A torch uses 300J of chemical energy. The light output is not 300J. Explain why.
4. Suggest a value for the light output in Q3.
5. Why would car manufacturers want to reduce dissipation as much as possible?

Answers:

1. Energy that spreads out and cannot be used
2. Heat and sound
3. Some energy is dissipated as heat
4. >300J
5. To make the cars burn less fuel for the same kinetic energy store

Intervention Questions:

1. What do we mean when we say "whenever energy is transferred, some energy is dissipated"?
2. How does particle movement relate to dissipation?
3. A motor uses 550J of electrical energy. The kinetic energy store output is not 550J. Explain why.
4. Suggest a value for the kinetic energy store output in Q3.
5. Why would torch manufacturers want to reduce dissipation as much as possible?

Answers:

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1. Whenever energy changes, some of the output energy is spread out and wasted
2. Dissipation is usually through sound and heating of surroundings, both of which involve particle movement
3. Some of the energy is dissipated as heat and sound
4. >550:
5. To get more light for the same amount of battery power; make the batteries last longer

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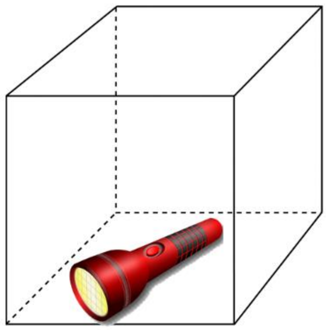
Conservation of Energy

Energy cannot be created or destroyed. The total amount of energy in the Universe has remained constant since the Big Bang and will remain constant until the end of the Universe.



Scientists sometimes refer to "closed systems". A closed system is a system where no energy can enter or leave. The universe is a closed system. A torch inside a perfectly sealed box is another. The principle of conservation of energy states that "in a closed system, the total amount of energy remains constant". This is another way of saying "energy can never be created or destroyed".

In the torch example, consider the energy changes. The battery may transfer 500J of its chemical energy to the bulb. The torch may then give out 400J of light energy, while 100J is dissipated as heat. Total energy in = total energy out.

Questions:

1. What does the "principle of conservation of energy" tell us?
2. If we made a hole in the box in the example above, it would no longer be a closed system. Explain why.
3. A car burns 400J of chemical energy. If 350J of kinetic energy store are produced, find the amount of wasted energy.
4. A device produces 34J of useful energy and 23J of wasted energy. Find the total energy that was input to the device.
5. A motor wastes 700J of energy. If it used 3000J of energy as input, calculate the useful output energy

Extension

The table shows values for a stone of mass 0.4kg, dropped from a height of 4m. Complete the table, then describe and explain the relationship between the stone's GPE and KE. Assume gravitational field strength is 9.8N/kg. Assume a closed system and that no energy is lost due to friction.

Height (m)	**4.0**	**3.0**	**2.0**	**1.0**	**0.0**
GPE (J)					
KE (J)					

Answers:

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1. The net energy in a closed system remains constant
2. Energy could join or leave the system
3. 50J
4. 57J
5. 2300J

Extension

The table shows values for a stone of mass 0.4kg, dropped from a height of 4m. Complete the table, then describe and explain the relationship between the stone's GPE and KE. Assume gravitational field strength is 9.8N/kg. Assume a closed system.

Height (m)	**4.0**	**3.0**	**2.0**	**1.0**	**0.0**
GPE (J)	15.68	11.76	7.84	3.92	0.00
KE (J)	0.00	3.92	7.84	11.76	15.68

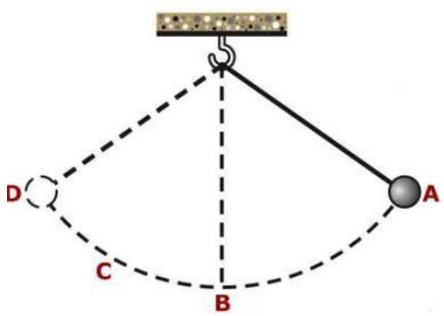
The total amount of energy remains constant at 15.68J. This figure is found by GPE = mgh = 0.4 x 9.8 x 4 = 15.68. As the stone falls it loses height and therefore GPE. This energy is transferred to KE. The KE is at the maximum level when the stone hits the ground at 0m. GPE + KE = 15.68 at all times.

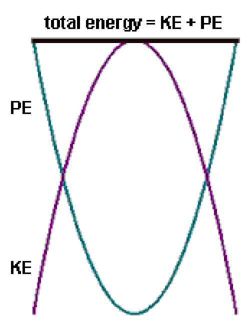
Intervention Questions:

1. True or false: Energy can be made and can disappear.
2. Why is the Universe described as a "closed system"?
3. A car burns 700J of chemical energy. If 250J of kinetic energy store are produced, find the amount of wasted energy.
4. A device produces 346J of useful energy and 234J of wasted energy. Find the total energy that was input to the device.
5. A motor wastes 960J of energy. If it used 3000J of energy as input, calculate the useful output energy

Extension

A pendulum bob is released at A and allowed to swing to D. Copy the graph and add labels A, B, C and D to show where the pendulum bob is at different times. Explain the shape of the graph. Assume a closed system and that no energy is lost due to friction.





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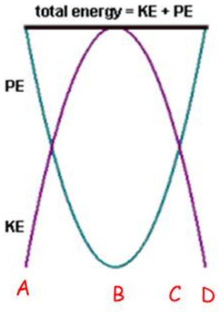
Intervention Answers:

1. False
2. No energy can enter or leave it
3. 450J
4. 580J
5. 2040J

Challenge:



At A, the bob has maximum GPE as it is at its maximum height, and 0KE as it is not moving. When it is released, it gains KE and loses GPE. At B, its height is lowest and it therefore has minimum GPE. It is at its maximum speed so KE is at maximum level. As it continues to C, it gains height and therefore GPE, but is slowing down and therefore reduces its KE. At D it has maximum GPE but no speed and therefore 0KE. GPE + KE add up to the same amount throughout.

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Reducing Unwanted Energy Transfers

Reducing unwanted energy transfers means that more of the input energy gets transferred to useful energy. This can benefit consumers as they can save money, and suppliers as they can offer their products more cheaply. It also benefits the environment as a lower energy input can mean less fossil fuel burned, or fewer raw materials used in e.g. battery manufacture.

Ways of reducing unwanted energy transfer:

Lubrication: In a car engine, moving parts have to do work against friction and waste energy as heat as a result of this. By adding lubrication to the moving parts, manufacturers can reduce the amount of friction and therefore reduce the unwanted energy transfer to heat.

Thermal insulation: People heat their homes and places of work using e.g. gas central heating – but an unwanted energy transfer occurs when heat travels out of the building to heat the surroundings. We can reduce this unwanted energy transfer by using thermal insulation: for example, cavity wall insulation and foil loft insulation.

The best materials for thermal insulation have low **thermal conductivity**: for example, foam. The higher the thermal conductivity the higher the rate of energy transfer by the material. Metal, for example, has a high thermal conductivity and therefore transfers heat energy across it quickly.

A building's rate of cooling is affected by two factors:

- Thickness of walls
- Thermal conductivity of walls

Questions:

1. Why do people want to reduce unwanted energy transfers?
2. Give an example of an unwanted energy transfer in a sewing machine
3. Explain how unwanted energy transfer is reduced in engines
4. Explain how unwanted energy transfer is reduced in heated buildings
5. Relate thermal conductivity to rate of energy transfer
6. How does the thickness of the walls affect a building's rate of cooling?
7. How does the thermal conductivity of the walls affect a building's rate of cooling?

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Answers:

1. To save money, to offer a better price to consumers, to save resources
2. Heat and sound
3. Lubrication is added to moving parts to reduce energy lost as heat due to friction
4. Thermal insulation is used to reduce unwanted heat transfer to the surroundings
5. The higher the thermal conductivity the faster the energy transfer
6. The higher the thickness of the walls the lower the rate of cooling
7. The higher the thermal conductivity of the walls the higher the rate of cooling

Intervention Questions:

1. State 3 advantages of reducing unwanted energy transfers
2. Give an example of an unwanted energy transfer in an electric lamp
3. Explain how lubrication is used to reduce unwanted energy transfer
4. Explain how thermal insulation is used to reduce unwanted energy transfer
5. To insulate your house, would you choose a material with a high or low thermal conductivity? Why?
6. To reduce unwanted energy transfer, would you choose thin or thick walls? Why?
7. What is the relationship between thermal conductivity of walls and a building's rate of cooling?

Intervention Answers:

1. Consumers can save money, producers can offer a cheaper product, the Earth's resources are conserved
2. Heat
3. Added to moving parts in an engine to reduce unwanted energy transfer through heating due to friction
4. In a heated building, thermal insulation is used to reduce unwanted transfer of thermal energy to the surroundings
5. Low thermal conductivity as the rate of energy transfer would be lower
6. Thick walls as rate of thermal energy transfer would be lower
7. The higher the thermal conductivity the higher the rate of cooling

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Efficiency

Efficiency is a measure of how good an appliance, machine or power station is at transferring the input energy to the desired output energy. It tells us the proportion of input energy that is transferred to useful output energy.

Whenever energy is transferred, some of the input energy is always transferred to wasted energy: it is impossible to achieve 100% efficiency.

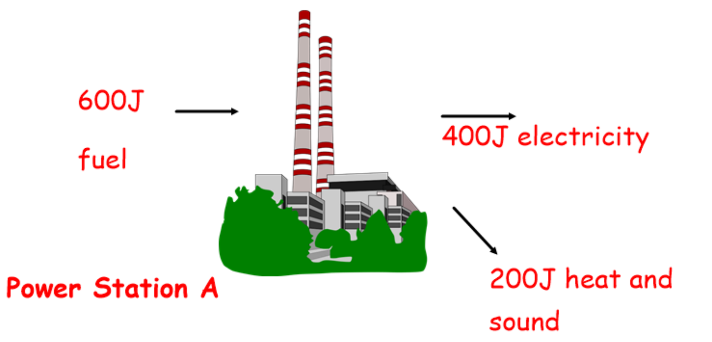
You need to memorise two equations on efficiency:

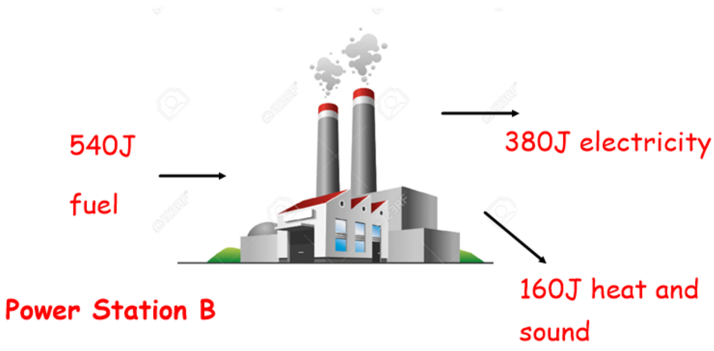
$$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \qquad \text{efficiency} = \frac{\text{useful power output}}{\text{total energy input}}$$

These are really just two versions of the same equation:
efficiency = useful out/total in.

Why do we want to know about efficiency?

The picture shows two power stations. It is difficult to tell at first glance which one gives better value for money: Power station A produces more electricity but it needs more fuel in order to do so. The efficiency equation allows us to compare the two power stations:





<u>Power Station A:</u>

efficiency = useful output ÷ total input

efficiency = 400 ÷ 600 = <u>0.67</u>

<u>Power Station B:</u>

efficiency = useful output ÷ total input

efficiency = 380 ÷ 540 = <u>0.70</u>

So we have found that Power Station B is the most efficient one.

<u>Changing the subject</u>

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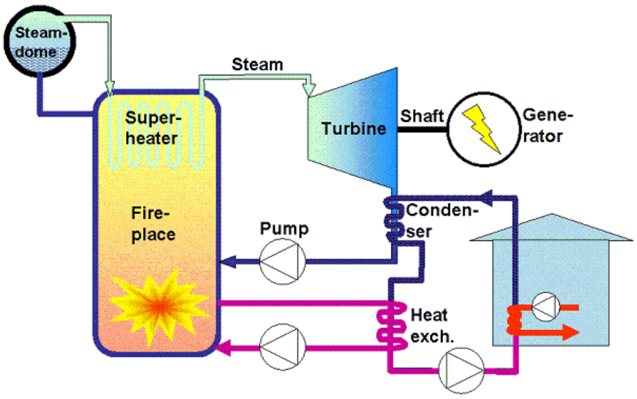
Example: A lightbulb with efficiency 0.45 emits 650W of light. What is the power input required?

Total input = useful output ÷ efficiency

Total input = 650 ÷ 0.45 = 1444.4W

HT: Increasing efficiency



If we want to increase efficiency, we need to turn some of the wasted energy output into useful energy output.

CHP (Combined Heat and Power) power stations do this by condensing the steam to hot water after it has turned the turbine, and pumping the hot water to nearby homes to be used for heating, rather than cooling it down at the power station before reusing it.

Modern condensing boiler heaters for homes use vapour created from heating water to pre-heat the cold water entering the boiler.

Questions:

1. What does the efficiency of an appliance tell us?
2. What are the two equations for efficiency?
3. Why would a more efficient motor give a car a higher top speed?
4. Why would more efficient light bulbs lead to a cheaper electricity bill?
5. What are the environmental arguments for developing more efficient appliances?
6. HT: Draw a flow chart to explain how a CHP power station works
7. HT: Explain why CHP power stations and condensing boilers are more efficient than their traditional counterparts

8. A lightbulb uses 470J of energy and produces 180J of heat and 290J of light. Calculate the efficiency of the lightbulb.
9. A power station uses 1900J of fuel and produces 1250J of electricity. Calculate the efficiency of the power station.
10. A loudspeaker uses 400W of power and produces 325W of sound, wasting 75W in thermal energy. Find the efficiency of the loudspeaker.
11. Find the efficiency of a car that uses 3890J of fuel to generate 2650J of kinetic energy store.

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12. What is the efficiency of a lorry that produces 5780J of kinetic energy store by burning 7850J of fuel?
13. A power station has efficiency 0.85. How much electricity is generated from 5000J of fuel?
14. A solar panel has efficiency of 0.32. If 870J of light fall on it, how much electricity is produced?
15. A car has efficiency 0.34. Find its kinetic energy store when it burns 4600J of petrol.
16. A lightbulb has efficiency 0.85. Calculate the power of the light produced when 600W of electricity is input.
17. Find the kinetic energy store of a lorry with efficiency 0.40 when it burns 10,000J of diesel.
18. A power station has efficiency 0.63. How much chemical energy must be burned in order to produce 850J of electricity?
19. A solar panel has efficiency 0.51. How much light energy needs to fall on it so that electricity output is 12J?
20. A car has efficiency 0.75 and kinetic energy store of 1200J. What is the energy value of the petrol burned to give this output?
21. A lorry has efficiency 0.24 and a kinetic energy store output of 5000J. Calculate the energy value of the fuel burned.
22. A lightbulb has efficiency 0.55 and a light output of 18W. Calculate the power input.

Extension

1. An electric heater consumes 960J of electricity. 180J of this is used to heat the internal parts of the heater. The remainder goes to heat the room. Calculate the heater's efficiency.
2. An electric motor uses 2.4×10^8 J of electrical energy to give a weight 1.8×10^7 J of gravitational potential energy store. Find the efficiency of the motor.
3. A lightbulb emits 3000J of light energy over a 20 second period. If the lightbulb's efficiency is 0.4, calculate the power input.
4. A pump uses petrol to pump water from a well 200m deep. Energy per gram of petrol = 48×10^3J/g. If the pump has efficiency 0.6, how much petrol is needed to raise 2kg of water?
5. A pulley system is used to lift different weights a height of 3m. The results are shown below:

Weight lifted (N)	25	75	130	180	230
Theoretical work done (J)					
Actual work done to lift (J)	179	357	542	720	885
Efficiency					

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a. Complete the table
b. Draw a graph of efficiency against load
c. Estimate the weight lifted when efficiency is 0.3

Essay

CHP power stations use the heat in the condensed steam to heat local houses. Evaluate the desirability of CHP power stations compared to traditional power stations. Include example calculations in your answer. (6)

Answers

1. What proportion of the total input energy is converted to useful output energy
2. Efficiency = useful energy out ÷ total energy in (1); Efficiency = useful power out ÷ total power in
3. Lower proportion of wasted energy so higher proportion of energy is converted to kinetic energy store
4. Lower proportion of wasted energy so less electricity needed for the same amount of light energy output
5. Less energy will be used ; so less burning of fossil fuels which contributes to global warming and less raw materials needed for other methods of energy production e.g. solar panels
6. Water is heated to create steam → steam moves (kinetic energy store) and turns a turbine to generate electricity → steam is condensed to make hot water → hot water is pumped to nearby homes to be used for heating
7. Some of the energy that would normally be wasted is used for a useful purpose

8. 0.62
9. 0.66
10. 0.81
11. 0.68
12. 0.74
13. 4250J
14. 278.4J
15. 1564J
16. 510W
17. 4000J
18. 1249.21J
19. 23.53J
20. 1600J
21. 20833.33J

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22. 32.73W

Extension

1. 0.82
2. 0.075
3. 375W
4. 0.14g

5.

Weight lifted (N)	25	75	130	180	230
Theoretical work done (force x distance) (J)	75	225	390	540	690
Actual work done to lift (J)	179	357	542	720	885
Efficiency	0.42	0.63	0.72	0.75	0.78

a. Complete the table
b. Draw a graph of efficiency against load

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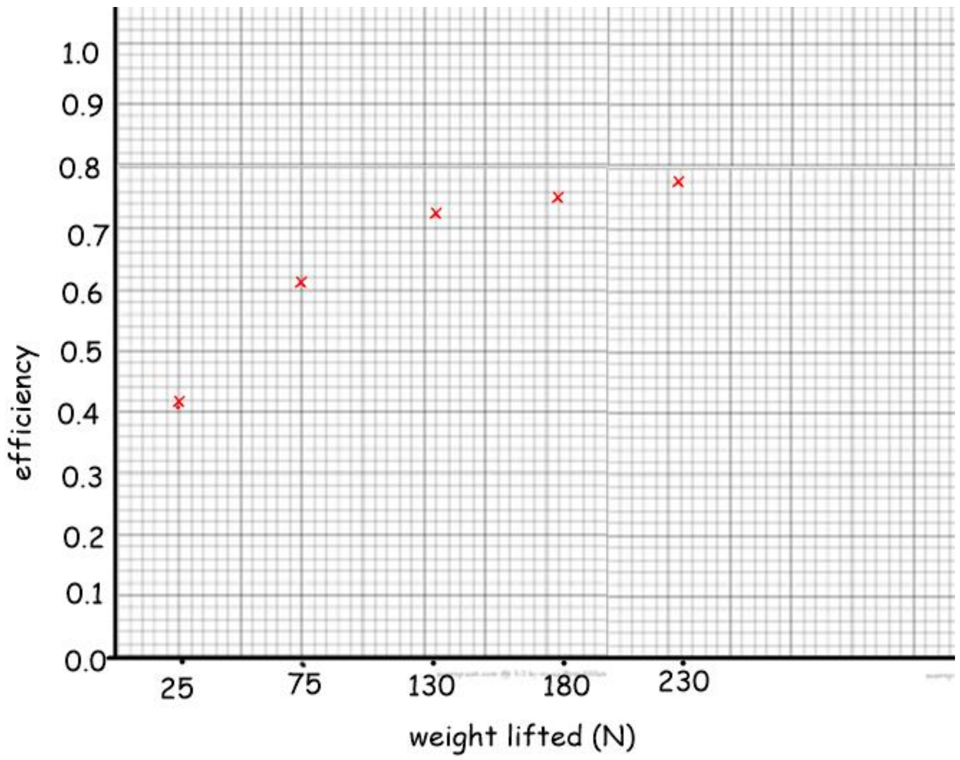

c. ~15N

Intervention questions

1. Define efficiency
2. Draw the formula triangle for efficiency and explain how to use it
3. Why can a more efficient motor lift a heavier load?
4. Why would more efficient electric heaters lead to a cheaper electricity bill?
5. What are the economic arguments for and against developing more efficient appliances?
6. HT: Draw a flow chart to explain how a condenser boiler works

7. A lightbulb uses 360J of energy and produces 150J of heat and 210J of light. Calculate the efficiency of the lightbulb.
8. A power station uses 7800J of fuel and produces 4250J of electricity. Calculate the efficiency of the power station.
9. A loudspeaker uses 2500W of power and produces 475W of sound. Find the efficiency of the loudspeaker.
10. Find the efficiency of a car that uses 4560J of fuel to generate 2650J of kinetic energy store.
11. What is the efficiency of a lorry that produces 5780J of kinetic energy store by burning 8970J of fuel?
12. A power station has efficiency 0.65. How much electricity is generated from 5000J of fuel?

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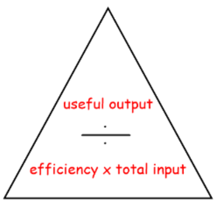
13. A solar panel has efficiency of 0.72. If 870J of light fall on it, how much electricity is produced?
14. A car has efficiency 0.54. Find its kinetic energy store when it burns 4600J of petrol.
15. A lightbulb has efficiency 0.15. Calculate the power of the light produced when 600W of electricity is input.
16. Find the kinetic energy store of a lorry with efficiency 0.48 when it burns 10,000J of diesel.
17. A power station has efficiency 0.60. How much chemical energy must be burned in order to produce 850J of electricity?
18. A solar panel has efficiency 0.65. How much light energy needs to fall on it so that electricity output is 12J?
19. A car has efficiency 0.35 and kinetic energy store of 1200J. What is the energy value of the petrol burned to give this output?
20. A lorry has efficiency 0.34 and a kinetic energy store output of 5000J. Calculate the energy value of the fuel burned.
21. A lightbulb has efficiency 0.85 and a light output of 18W. Calculate the power input.

Intervention: Answers

1. The proportion of input energy a device transfers to useful output energy
2. 

Determine the unknown, cover it up, and perform the calculation visible.
3. Less input energy is wasted , more input energy is transferred to kinetic energy store
4. Less energy used in heating the heater , more energy used in heating the room
5. Against: Developing new appliances costs money For: more efficient appliances will reduce electricity bills ; more efficient appliances could be more popular with consumers
6. Electricity or gas used to heat water. → Vapour collected and condensed. → Heat used to pre-heat more water.
7. 0.58
8. 0.54
9. 0.19
10. 0.58
11. 0.64

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12. 3250J
13. 626.4J
14. 2484J
15. 90W
16. 4800J
17. 1416.67J
18. 18.46J
19. 3428.57J
20. 14705.88J
21. 21.18W

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