Heat energy and temperature
الطاقة الحرارية و درجة الحرارة
### Standards

8.17.1 Know that temperature is a measure of how hot something is and the common unit of temperature is the degree Celsius.

8.17.2 Know that the amount of heat energy in an object depends on the mass of the object and what it is made of as well as how hot it is.

8.17.3 Know that heat is transferred by conduction, convection and radiation, and cite everyday examples of each.

8.17.4 Know that some materials are better conductors of heat than others; know the differences in the ability to conduct heat between solids, liquids and gases, and between metals and non-metals, and know some applications of these differences.

8.17.5 Explain the cause of convection currents in air and water.

8.17.6 Show how convection currents in air cause weather features

8.17.7 Know that the nature of a surface influences how well it absorbs and radiates heat.

8.17.8 Know that heat can be radiated through a vacuum and that this is how the heat from the Sun reaches the Earth.
The objectives:
1- Know that temperature is a measure of how hot something is.
2- Know the common unit of temperature.
3- Know the factors that amount of heat energy depend on.

Key words

<table>
<thead>
<tr>
<th>Heat</th>
<th>الطاقة الحرارية</th>
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<tr>
<td>Joule</td>
<td>الجول/وحدة قياس الطاقة</td>
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<tr>
<td>Temperature</td>
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<td>Factor</td>
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<tr>
<td>Thermometer</td>
<td>الترمومتر/أداة قياس الحرارة</td>
</tr>
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</table>
What happens when we mix hot and cold?
How much heat is needed?

How are temperature and heat energy different?

We have all noticed that when you heat something up, its temperature rises. Often we think that heat and temperature are the same thing. Heat and temperature are related to each other, but are different concepts.

Heat can increase or decrease the temperature. If we add heat, the temperature will become higher. If we remove heat the temperature will become lower.

Temperature is not energy, but heat is energy.
Why things cool down or warm up?

- A hot drink cools down until it is the same temperature as the room.
- A cold drink warms up until it is the same temperature as the room.

As hot drinks cool down, it is losing energy. Energy escapes from hot objects, and spreads into colder ones.

When energy moves from a hotter place to a colder place, we say that heat energy is flowing.

- Heat energy always flows from a hotter place to colder one.

In the winter, we need more food than in the summer. Our body works hard to stay at 37\(^\circ\)c, but on a cold day, energy escapes from our body more quickly.
Temperature is measured by a device called thermometer. The temperature should always be stated with its unit, °C. The normal temperature of human body is 37°C. Thermometer should be washed before and after use, preferably with an antiseptic solution.

Two things can have the same temperature but contain different amount of heat energy. Let’s look at two examples to explain this.

1. Two beakers of water at 50 °C are at the same temperature, but if one is twice as big as the other, it will contain twice as much heat energy (A and B).

2. A breaker with hot liquid in it will contain more heat energy than one with cooler liquid of the same volume (A and B).

في فصل الشتاء، نحن بحاجة إلى مزيج من المواد الغذائية من الصيف. لأن أجسامنا تعمل جاهدة للبقاء في درجة 37. ولكن في يوم بارد، نكرب الطاقة من الجسم بسرعة أكثر.

**Thermometer**
2. The cup which contains hot water will contain more heat energy than the same cold cup of the same volume.

- We can think of temperature as:

The average amount of energy per particle.

And it is measured by Celsius.

And heat energy as:

The total amount of energy of all particles in the material.

And it is measured by Joule.

So far we have only looked at different temperatures and the heat energy in different amounts of water. How much the temperature of a material is changed by heat energy depends on two things:

- what the material is
- How much of it there is.

If an electric heater puts 4200 J of energy in 100g of water it will warm it up by 10°C. It will take 8400 J of energy to warm 200g of water by 10°C. Twice as much water needs as much energy of raise its temperature by the same amount.
• What kind of materials (types) are we working with?
• How much of each material is there?

If the heater gave 4200 joules of energy to 100 grams of water, the temperature of the water increased by 10 degrees Celsius.

But if we need to raise the temperature of 200 grams of water by 10 degrees Celsius, we will need 8400 joules of energy. This means that doubling the amount of water requires half the amount of energy to raise the temperature by the same amount.

* 1 kilogram of water needs 4200 joules of energy to raise its temperature by 1°C.

How much energy is needed to increase the temperature of 1 kilogram of water by 5°C?

If you use aluminum instead of water, you will need a different amount of energy to warm it by 1°C.

* 1 kilogram of aluminum needs 880 joules of energy to raise its temperature by 1°C.

It takes 8400 joules of energy to raise the temperature of 1 kilogram of aluminum by about 9.5°C.

8400 J

Temperature rise of about 9.5 °C

Same energy into each material

8400 J

Temperature rise of about 2 °C
# Compare between heat and temperature

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<th>Temperature</th>
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<td>كيفية القياس</td>
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<tr>
<td><strong>Unit</strong></td>
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<td>الوحدة</td>
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The factors affecting the amount of heat energy are:

1. ...........................................................................................................
2. ...........................................................................................................
3. ...........................................................................................................
The objectives:
1- Know that heat energy is transferred by conduction, convection and radiation and cite everyday examples of each.
2- Know that some materials are better conductors of heat than others.
3- Know the differences in the ability to conduct heat between solids, liquids and gases and between metals and nonmetals.
4- Know some applications of these differences.

Key words

<table>
<thead>
<tr>
<th>Conduction</th>
<th>التوصيل</th>
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<tr>
<td>Convection</td>
<td>الحمل أو النقل الحراري</td>
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<td>Radiation</td>
<td>الإشعاع</td>
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<td>Conductor</td>
<td>موصل</td>
</tr>
<tr>
<td>Insulator</td>
<td>عزل</td>
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</table>

There are three ways in which heat can be transferred. Here is a "model" to help us see the difference between the three ways. Three ways of getting a book to the back of the class.

هناك ثلاثة طرق يمكن من خلالها نقل الحرارة. • هنا "نموذج" لمساعدتنا على معرفة الفرق بين الطرق الثلاث. ثلاث طرق لنقل الكتاب إلى الجزء الخلفي من غرفة الصف.
Figure 2

1- **Conduction:** a book can be passed from person to person - just as heat is transferred from atom to atom.

2- **Convection:** a person can walk to the back of the class carrying the book. This is the way hot air moves in convection, taking the energy with it.

3- **Radiation:** a book can be thrown to the back of the class rather like the way energy is radiated from a hot object.
1- CONDUCTION

After five or 10 minutes the whole length of this metal rod is hot. Heat has been transferred along the rod by conduction.

**The heat energy is conducted from the hot end to the cold end. It is transferred from atom to atom. At the hot end the atoms are vibrating a lot, this vibration is gradually passed along to the other atoms as they bump into each other.**
Conduction: Is transfer of heat energy from a place with high temperature to another with lower temperature through direct contact.

التصويل: هو نقل الطاقة الحرارية من مكان ذو ارتفاع في درجة الحرارة إلى آخر مرتفع في درجة الحرارة من خلال الاتصال المباشر.

Conductors and insulators:
المواض الموصلة والمواد العازلة

Experiment:
Set up the test tube as show at the picture and aim a gentle Bunsen flame just below the surface of water until boils at the tip, without hearting your hand.

Is the cube of ice melt?
Is water a good conductor or poor conductor?

تجربة :
قم بإنشاء أنبوب الاختبار كما يظهر في الصورة وجه لهب بزن فقط تحت سطح الماء حتى يغلي على الحافة ، دون إذاء يدك.

هل يذوب مكعب الثلج؟
هل الماء موصل جيد أو موصل ردئ للحرارة؟

Figure 4
**In solids the closeness of the particles enables the vibrations caused by heat energy, to move quickly. So the conduction happens in solids.**

In the solid state, the closeness of the particles allows the vibrations caused by heat energy to move quickly, enabling the conduction of heat. This is in contrast to liquids and gases, where the conduction is much slower due to the larger distances between particles.

---

**Conductor:**

Is a material that allows heat to move through it fairly easily.

**Insulator:**

Is a material that only allows heat energy to move slowly through it.

---

Water like most liquids is a poor conductor of heat. So poor that it is possible to have frozen water and boiling water just a few centimetres apart.

Gases are worse conductors than liquids. They are in fact excellent insulators.

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Gases are worse conductors than liquids. They are in fact excellent insulators.
- A good saucepan is made from the materials that are *conductors* and *insulators*. The base and sides of the pan are made of metal so that heat is easily conducted from the flame to the food. The handle is made from an insulator so that it does not become too hot to hold.

- The air trapped in and between our clothes and blankets keeps us warm.

- In the same way, the air trapped in fur and feather keeps animals warm. Birds fluff up their feathers in winter to trap more air.

- A refrigerator has insulation material round it to keep it *cold*. The insulation reduces the amount of heat conducted to the inside from the warmer room.
Insulating the home: عزل المنازل

Figure 6

This diagram shows how heat may escape from a house that has not been insulated:

- 10% through windows, reduced by installing double glazing.
- 25% through roof, reduced by putting insulation into loft.
- 25% through walls, reduced by having cavity wall insulation.
- 15% through floor, reduced by fitting carpets and underlay.
- 25% through gaps and cracks around doors and windows, reduced by fitting draft excluders.

Glass fibre is an excellent insulator because it contains large amounts of trapped air. It is placed in the loft to reduce heat loss.

- It is the layer of air trapped between the two panes of glass that make double glazing an excellent method of reducing heat loss from a house.

- The metal blade of a knife conducts heat away from your fingers and so feels cold. Plastics are good insulators so the plastic handle does not conduct heat away and so feels warm.

Woven materials, e.g. wool and cotton contain trapped air and are excellent insulators.
Lab Report

Research question: How does heat energy transfer in solid?

Materials: iron ruler, paraffin wax, iron nails, Bunsen burner.

Procedure:
1. Fix some drawing pins using wax.
2. Hold one end using holder and heat the other end.

Observation:
1. Which pin will fall first?

2. Which pin will fall the last one?
Conclusion: 

Heat transfers in solid by ________________________.

Conduction:

________________________________________________________________________

Experiment 2:

1. Get three rods of different materials (Copper, iron, glass).
2. Fix a small nail at one end of each rod.
3. Heat the other end.

Observation:

Which nail drops first?

اى المسامير يسقط اولا؟
How many minutes does it take for the 1st and the 2nd nail to drop?

كم دقيقة يتغرق المسمار الأول والثاني للسقوط؟

Conclusion:

1. ___________ and ___________ are good conductors of heat, while ___________ is bad conductor of heat.

2. Thermal Conductors:

المواد الموصلة للحرارة:

3. Thermal Insulators:

المواد الغير الموصلة للحرارة:
**Experiment 3**
Hold a match about 1 cm from a flame.

**Observation:**
Will the match burn?

**Conclusion:**
Air is a good ___________ and a bad ___________ of heat.

**Give Reasons:**
Woolen clothes are insulators.

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**تجربة 3**
امسك بعود الثقاب على مسافة حوالي 1 سم من لهب.

**الملاحظة:**
هل يشتعل عود الثقاب؟

**الاستنتاج:**
ماذا تستنتج من التجربة.

**علل:**
الملابس الصوفية تعتبر من العوازل؟
Work sheet

Classify the following into thermal conductors and thermal insulators:

<table>
<thead>
<tr>
<th>Thermal Conductors</th>
<th>Thermal Insulators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood, iron, plastic spoon, woolen clothes, copper, cooking pan, handle of cooking pan, glass, aluminum.</td>
<td></td>
</tr>
</tbody>
</table>

الخشب ، الحديد ، ملعقة من البلاستيك ، الملابس الصوفية ، النحاس ، اناء الطبخ ، مقبض اناء الطبخ ، الزجاج ، الألومنيوم.
The objectives:
1- Explain the cause of convection currents in air and water.
2- Show how convection currents in air cause weather features.

Key words

| Convection | الحمل الحراري |
| current | تيار |
| breezes | نسيم |

- After several minutes all the liquid / gas in the container have been warmed, i.e. heat has been transferred to all parts.

- This circular movement of fluid is called convection current.

- Convection can't take place in a solid. The particles of a solid are unable to move position.

بعد عدة دقائق كل السائل / أو الغاز في الأانة سيصبح ساخنا، تم نقل الحرارة أي إلى جميع الأجزاء.

- لا يمكن للحمل الحراري ان يحدث في الحالة الصلبة. لأن جزيئات المواد الصلبة غير قادرة على الحركة.
Convection is: The movement of the liquid and gases due to the heat.

الحمل الحراري هو: حركة المواد السائلة والغازات بسبب الحرارة.

How does convection happen?
كيف يحدث تيار الحمل الحراري؟

A liquid or gas is warmed. The fluid expands, becomes less dense and rises carrying its extra energy with it. The warmer fluid is replaced with cooler fluid which is then heated.

عندما يسخن السائل أو الغاز فإنه يتمدد، وتقل كثافته ويرتفع لآعلى حاملا معه الطاقة الزائدة. يتم استبدال السوائل والغازات الدافئة باخرى باردة حتى يتم تسخينها هي أيضاً.

Heating the room by convection:
تدفئة الحجرة باستخدام الحمل الحراري
Radiators are badly named. Most of the heat they give to a room is transferred not by radiation but by convection.

Figure 1

Convection currents in oven and fridges

Figure 2

TO HEAT THE WHOLE OF AN OVEN THE HEAT SOURCE MUST BE AT THE BOTTOM.

Figure 3

‘Cooler’ or freezing compartment

TO COOL THE WHOLE OF A FRIDGE THE ‘COOLER’ MUST BE PLACED AT THE TOP. WARMER AIR RISES AND IS REHEATED.

Coastal breezes

نتبريد الثلاجة بالكامل يجب وضع وحدة التبريد في الاعلى لتسخين الفرن بالكامل يجب وضع وحدة التسخين في الأسفل يتم نقل البرودة في الثلاجة والحرارة في الفرن باستخدام طريقة الحمل الحراري.
Convection also causes breezes on the coast on warm days. During the day the land is heated by the sun more quickly than the sea. This happens because the heat capacity of the water is larger than the heat capacity of the land.

Convection causes the air above the land to rise. Cold air blows in form the sea to replace the air that has risen, causing an onshore breeze. At night this reversed the land cools more quickly than the sea and convection currents create an offshore breeze.

يتسبب الحمل الحراري في النسيم على الساحل في الأيام الحارة. أثناء النهار ي祖国 الأرض من الشمس بسرعة أكبر من البحر. يحدث هذا لأن السعة الحرارية للمياه أكبر من السعة الحرارية للأرض. الحمل الحراري يتسبب في ارتفاع الهواء فوق البحيرة مسببًا الضربات الجوية الباردة. ويحل هواء جديد محل الهواء الذي ارتفع، مما يتسبب في نسيم البر. أثناء الليل يتبرد الأرض بسرعة أكبر من المياه متسببة في تيارات هوائية أو نسيم البحر.
**Experiment 1:**

1. Fill a beaker with water and add some saw dust.
2. Heat the beaker until boiling.
3. Observe the movement of the saw dust.

**Observation:**

________________________
________________________

**Conclusion:**

a. When water molecules is heated, their temperature __________, they __________, their density ___________ so the hot water molecules _____________ and the cold molecules ___________.

b. Heat transfer in liquid by _________________.

**Experiment 2:**
1. Cut a paper on a spiral form and hang it.
2. Put a candle under the spiral paper.

تجربة 2:
1. قطع ورقة على شكل حلزوني وقم بتعليقها.
2. ضع شمعة تحت الورقة الحلزونية.

Observation:
__________________________________________________________________________________________________________________________

Conclusion:
a. When air molecules is heated, their temperature ________, they ____________, their density ___________ so the hot air molecules __________ and the cold molecules __________.
b. Heat transfer in air by _____________________.

Define: Convection
__________________________________________________________________________________________________________________________

Draw the direction of the air movement near the beach during the day

ارسم اتجاه حركة الهواء بالقرب من الشاطئ أثناء النهار

Draw the direction of the air movement near the beach during the night.

sea Land
رسم اتجاه حركة الهواء بالقرب من الشاطئ أثناء الليل
3- RADIATION
الإشعاع

The objectives:

1- Know that heat can be radiated through a vacuum and that this is how the heat from the Sun reaches the Earth.
2- Know that the nature of a surface influences how well it absorbs and radiates heat.

<table>
<thead>
<tr>
<th>absorb</th>
<th>吸</th>
<th>متصب</th>
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<tbody>
<tr>
<td>radiate</td>
<td>شع</td>
<td>يمكنك</td>
</tr>
<tr>
<td>vacuum</td>
<td>الفضاء / الفراغ</td>
<td></td>
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</tbody>
</table>

Heat travels from the Sun to the Earth as waves (radiation). There are no particles between the Sun and the Earth’s atmosphere so heat cannot travel by conduction or convection.

لا تحتوي المسافة الفاصلة بين الأرض و الشمس على أي جزيئات، ولذلك لا تنتقل الحرارة من الشمس إلى الأرض ولا بالتوصول ولا بالحمل الحراري. تنتقل الحرارة من الشمس إلى الأرض بالإشعاع.
**Experiment (1):**
Get two cans of equal size, one that is **polished and shiny** on the outside and one that is **black and dull**. Each one should have lid. Put a thermometer in each and pour in equal amounts of hot water. Let them cool, side by side. Stir the water and take their temperatures every minute.

- Which can cools down more quickly?
- Which can is losing energy more quickly?

- A dull black surface **loses energy more quickly**—it is a good radiator.
- A bright shiny surface **is a poor radiator**.

The dull black surface loses energy more quickly, so it’s a good radiator. The bright shiny surface loses energy more slowly, so it’s a poor radiator.

---

**Emitting Radiation**

Warm objects give off or **emit heat radiation.**

(How do you know a radiator is hot without touching it?)
Experiment (2):
Use the same two cans as in experiment (1), but this time pour in equal amount of cold water.
Place the two cans in full sunlight or place them equal distance from an electrical fire. Stir and take the temperatures every minute.

- Which can heats up more quickly?
- Which can is absorbing energy more quickly?

- A dull black surface is a good absorber of radiation (as well a good radiator). It takes in and gives out a lot of radiation.
- A bright shiny surface is a poor absorber of radiation, it reflects the radiation away.
- In the same way, petrol storage tanks (and sometimes Factory roofs) are sprayed with silver paint to reflect the sun’s rays.
A fire fighting suit is bright and shiny so that it does not take in a lot of energy and burn the fire fighter.

In hot countries, people wear bright white clothes and paint there houses white to reduce absorption of energy from the sun.
**Experiment 1:**
Put your hand under electric bulb.

**Observation:**
What do you feel?
_________________________________

**Analysis:**
Does the heat transfer to your hand by conduction? Why?
__________________________________________
__________________________________________
Does the heat transfer to your hand by convection? Why?
__________________________________________
__________________________________________

**Conclusion:**
Heat transfer in gases and vacuum by _______________________.

**Radiation:**
____________________________________________________________________________________
Heat transfer from the earth to the sun by radiation. Explain why heat does not transfer by conduction, or by convection.

نقل الحرارة من الأرض إلى الشمس بالإشعاع. اشرح لماذا لا يتم نقل الحرارة عن طريق التوصيل، أو عن طريق الحمل الحراري.

__________________________________________________________

Does the nature of a surface influences how well it absorbs and radiates heat?
هل تؤثر طبيعة السطح على كيفية امتصاصها وطلاقها للحرارة؟

Complete the following sentences:

1. A dull black surface is a good ___________ of radiation and a __________ radiator.

2. A __________________ surface is a poor absorber of radiation and a poor _________________.

Q1: Which of the following is an example of heat transfer by radiation?

1- Water moving in a pot of boiling water
2- The warmth you feel sitting near a fire
3- Warm air rising from hot pavement
4- The warmth you feel holding a cup of hot cocoa

أي مما يلي مثال على نقل الحرارة عن طريق الإشعاع؟

1 - نقل المياه في وعاء من الماء المغلي
2 - إن كنت تشعر بالدفء عندما تجلس قرب النار
3. ارتفاع الهواء الدافئ من الرصيف الساخن
4. إن كنت تشعر بالدفء عند امساكك بكوب من الكاكاو الساخن.

Q2: Write the scientific term:

1. ------------- is the energy that moves from one object to another.
2. ------------- is a material that allows heat to move through it easily.

التفنن المصطلح العلمي:

1. ------------- هي الطاقة التي تنتقل من كائن إلى آخر.
2. ------------- هي المواد التي تسمح بانتقال الحرارة من خلالها بسهولة.

Q3: What are the three types of energy transfer?

ما هي الطرق الثلاثة لنقل الطاقة الحرارية؟

1. __________________
2. __________________
3. __________________

Q4: Write the suitable term of transferring heat under each picture:

اكتب طريقة نقل الحرارة تحت كل صورة من الصور الآتية:

![Picture 1]

________________________

________________________

________________________

Explain the following observations:
a. Metal kettles and pans usually have plastic or wooden handles.

الغلاٌات المعدنٌة والمقالي عادة ما يكون مقابضها من البلاستٌك أو الخشب.

b. Windows in air-conditioned buildings often consist of two layers of glass with an air space in between them.

النوافذ في المبانٌ مكٌفة الهواء تكون غالبااً من طبقتين من الزجاج يفصلهما حاجز هوائي.

c. In some windows in modern buildings, the glass is coated with a very thin transparent layer of metal.

في بعض النوافذ في المبانٌ الحديثة، يغطى الزجاج بطبقة شفافة رقيقة من المعدن.

d. Car radiators are always painted matt black.

دائمااً ما يغطى مشعات الحرارة للسيارات بطبقة سوداء اللون.

e. Hot water heaters are usually surrounded by a layer of polyurethane foam.

عادة ما يحاط سخانات المياه بطبقة من الفلين الأبيض.

f. Why does conduction occur more easily in solids and liquids than in gases?

فسر سهولة عملية التوصٌل في المواد الصلبة والسائلة عن الغازية.