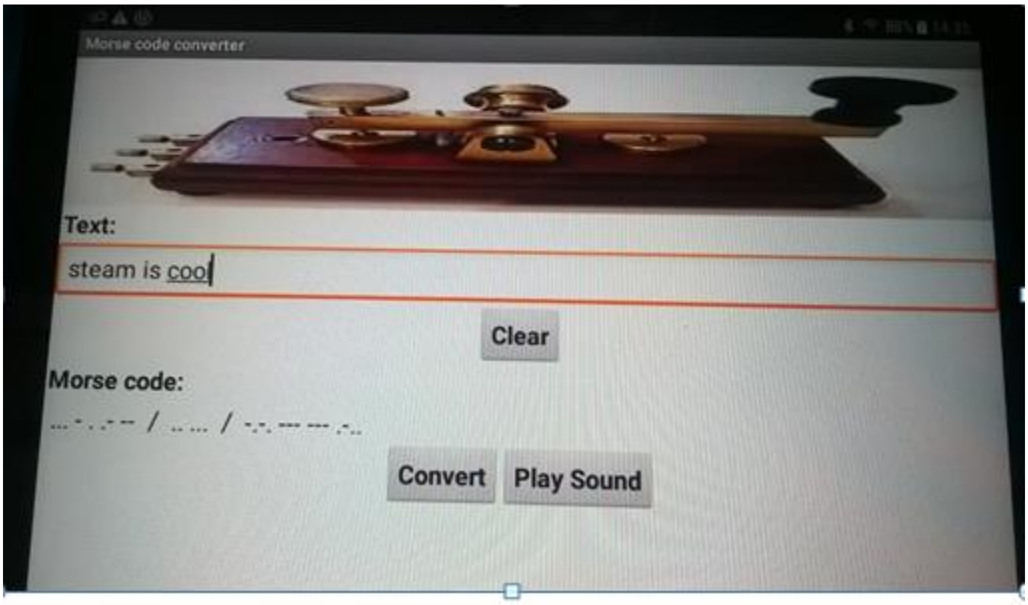


From Marconi to mobile apps

INTRODUCTION

Who was Marconi?

Marconi is primarily known for his invention of wireless telegraphy. Like Popov in Russia and Branly in France he started from the work of Hertz. In 1890 and after many attempts he managed to send wireless signals over a distance of more than two kilometres.

To achieve this he used a spark gap transmitter and – his invention – the radio antenna. Soon this led to wireless communication between England and France. In 1901 he was the first to send wireless Morse signals across the Atlantic Ocean.

In this lesson set we will be introduced into the basics of wireless communication.

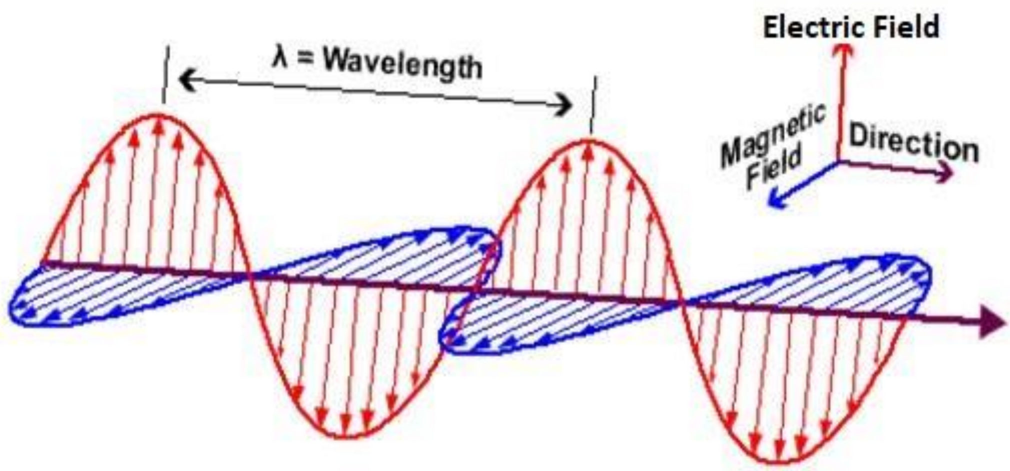
PART 1

Topic	Communication
Subjects	Science, Technology, Engineering
Level	★
Aims	Students learn about the history of communication, from Oersted to Marconi. They learn to code and decode in Morse. Students make their own Morse key and Morse player and are able to optimize the program. Students understand the principle of wireless communication through the Hertz experiment.
Skills	Science : Hertz experiment– history of electromagnetism Technology: using an app to send Morse signals Engineering : making a Morse key and Morse player with light and sound, using an Arduino / optimizing the program so that a Morse beginner can code and decode a text Maths : coding and decoding in Morse
Duration	150 minutes
Resources	Arduino uno 2 LED lights, 2AA batteries, a battery holder, a washing pin, electric wires with solid core, a buzzer, 7 wires with two pins (male-male), 3 220 ohm resistors

ELECTROMAGNETIC RADIATION

What are electromagnetic waves?

Electromagnetic radiation is the propagation of electric and magnetic vibrations through space. The electromagnetic wave moves in the direction of the arrow, perpendicular to the directions of the magnetic and electric field.



https://physics.stackexchange.com/questions/171144/do-electromagnetic-waves-occupy-varying-amounts-of-space-or-do-they-simply-vary

To see a simulation, click http://seilias.gr/html5/em/emWave-en.html

Why are these waves so important for wireless communication?

They move faster than sound waves.

They move through a vacuum while sound waves don't.

The energy of the wave is less absorbed by the surroundings than with sound waves.

HISTORY OF COMMUNICATION

Activity 1

Match the year to the people and their inventions

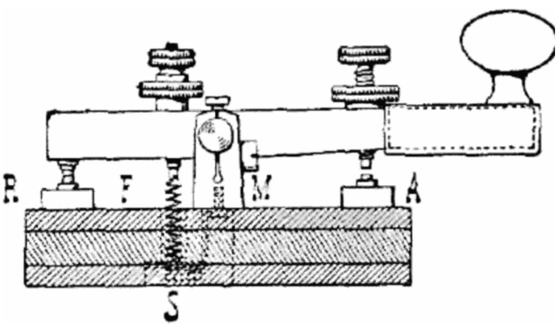
1819 – 1831 -1844 -1864 -1886-1901

Oersted discovers that a magnetic field is created when electric current moves through a wire.	**Maxwell** delivers mathematical proof for the existence of electromagnetic waves.	**Marconi** realises the first transatlantic communication.
1819	1864	1901
Morse manages to send Morse signals through a copper wire.	**Faraday** discovers that when the magnetic field changes a changing electric field is induced.	**Hertz** demonstrates by experiment that electromagnetic waves exist.
1844	1831	1886

Morse

Morse developed a code that consists of signals that are sent at intervals and represent letters and numbers. He used a Morse key. Pressing the key down meant "current"; the key in neutral position meant "no current".

Morse worked with two symbols: "dits" and "dahs". A dah signal was three times as long as a dit signal. In between symbols he left an interval with the length of a dit signal. We can also represent the code in dots and dashes.



Activity 2

Perhaps you know this very well-known signal. ...---...

What does it mean? SOS (later explained as Save Our Ship or Save Our Souls)

People familiar with Morse would read this signal as:

DiDiDit DahDahDah DiDiDit

How is S represented in Morse?

How many symbols does it consist of?

How is O represented in Morse?

How many symbols does it consist of?

We want to represent all letters of the alphabet and all numbers in Morse. We can already represent two letters by each time using 1 symbol. This way "-" will represent the letter T and "." represents the letter E.

How many letters can you represent with two symbols?

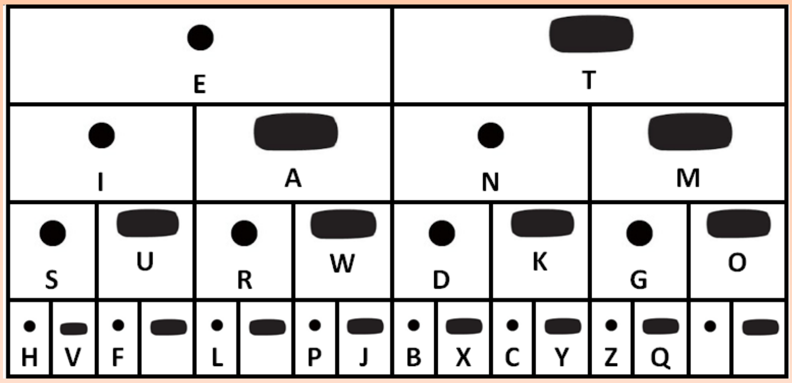
We want to represent all 26 letters and 10 numbers. What will be the maximum number of symbols we will need to represent a letter or a number?

Now that we can represent all letters and numbers we can also start forming words. Therefore we also need to know how to represent the end of a letter and the end of a word. The end of a letter is represented by a 3 dit interval, the end of a word by a 7 dit interval. In the dit and dash code we can indicate the end of a letter with / and the end of a word with //.

Activity 3

Let’s try to decode our first message. The grid below can be a great help. Read it from top to bottom.

You get to the letter V, by first selecting the top left hand box, left again on the next level, once more left and finally right. This way you see that V is represented by the combinarion dot dot dot dash.



Decode the message underneath :

.../-/./.-/--//../...//-.-./---/---/.-..//

Activity 4

Now it’s time to write your first message. This grid can help you with that.

Don’t forget the end of a letter (/) and the end of a word (//).

Write a message and pass it to an other pupil for decoding.

Letter	Morse	Letter	Morse	Cijfer	Morse
A	·—	N	—·	0	—————
B	—···	O	———	1	·————
C	—·—·	P	·——·	2	··———
D	—··	Q	——·—	3	···——
E	·	R	·—·	4	····—
F	··—·	S	···	5	·····
G	——·	T	—	6	—····
H	····	U	··—	7	——···
I	··	V	···—	8	———··
J	·———	W	·——	9	————·
K	—·—	X	—··—		
L	·—··	Y	—·——		
M	——	Z	——··		

Activity 5

Use the app “morse_converter.apk”, which was made with App Inventor, to convert ‘SOS’ into Morse sound.

Write a short word and listen.

Now also try to decode each other’s message in sound. Not that easy, don’t you think?

Keep practicing for a while.

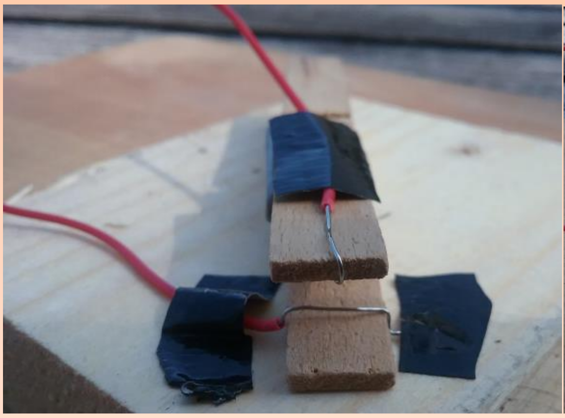
Activity 6

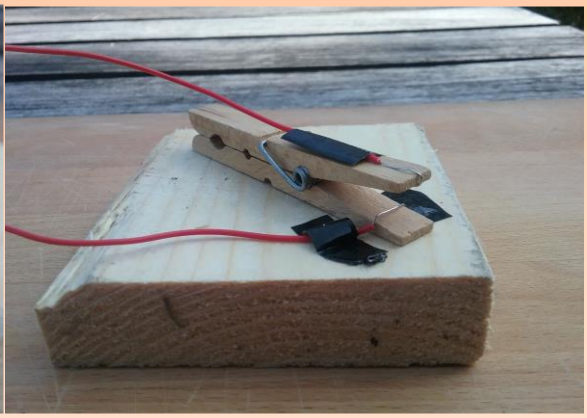
In the next activity we make our own Morse key.

Resources: two AA batteries, a battery holder, a washing pin nailed to a wooden board, two wires with a solid core, a 3V LED lamp and sticky tape.

Setup:

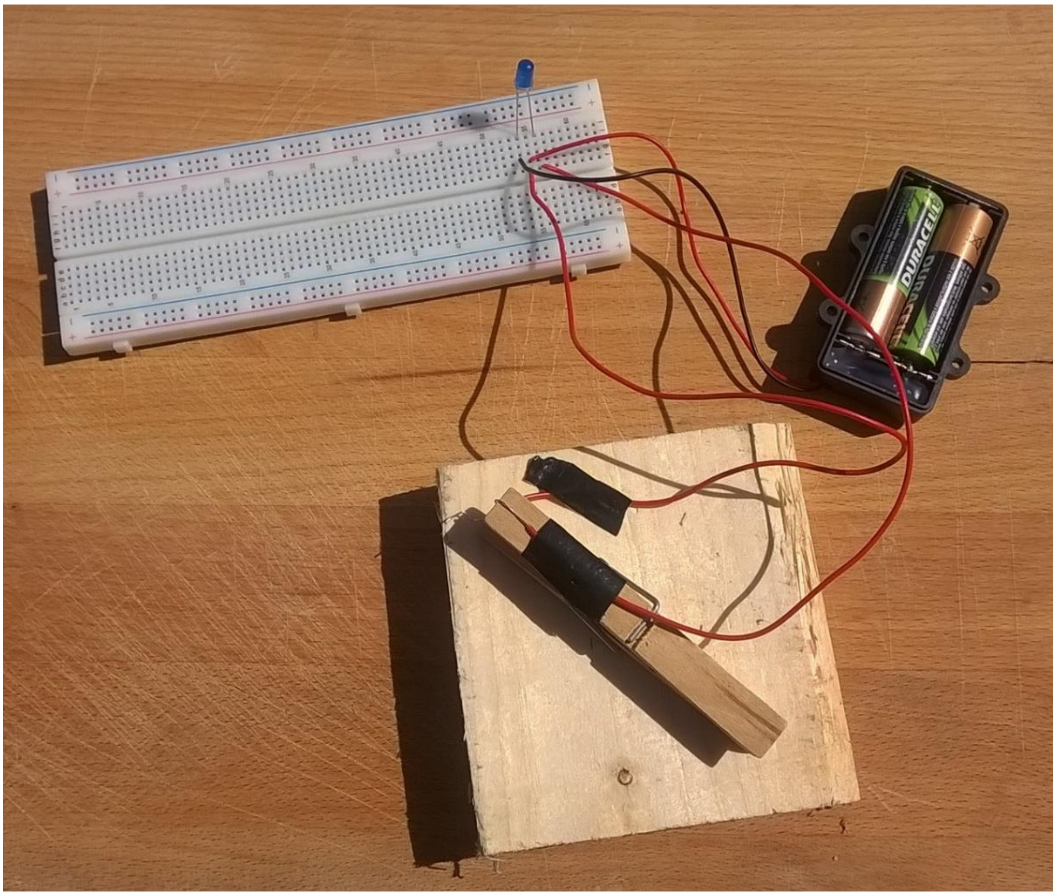
First we make the on/off button, using the washing pin. Make sure the wires touch when you push the washing pun.

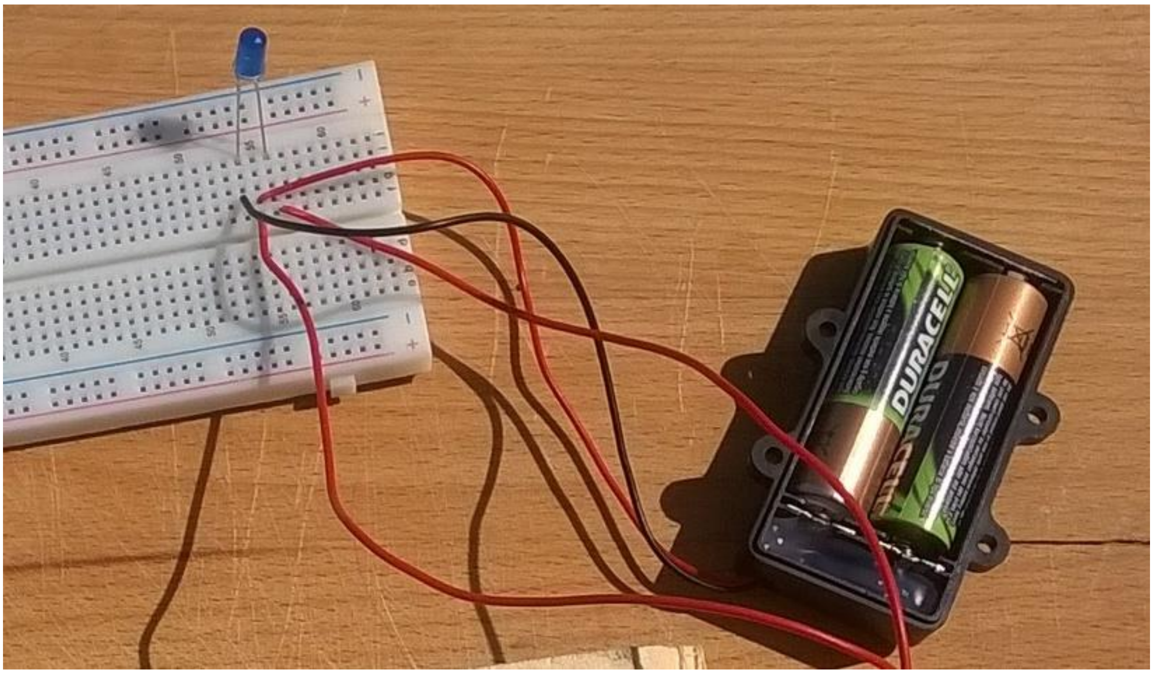




Next we make our electrical circuit. The red wire of the battery holder is the + pole, the long leg of the lamp is also the + pole. Make a correct circuit.

Test if the lamp burns when you close the circuit and signal some words to each other.


DURACELL


DURACELL

Activity 7

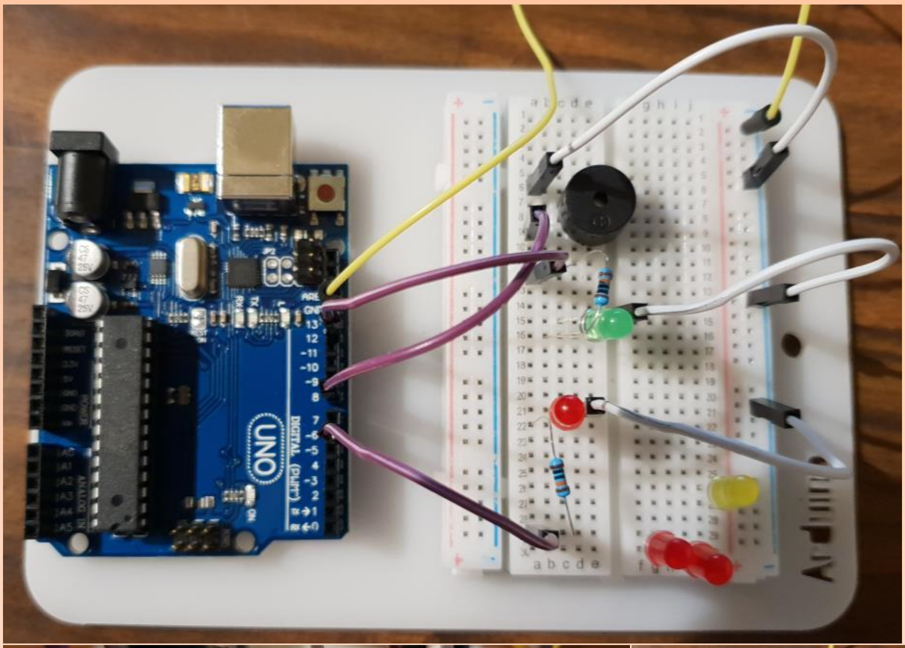
In the next activity we make our digital Morse player..

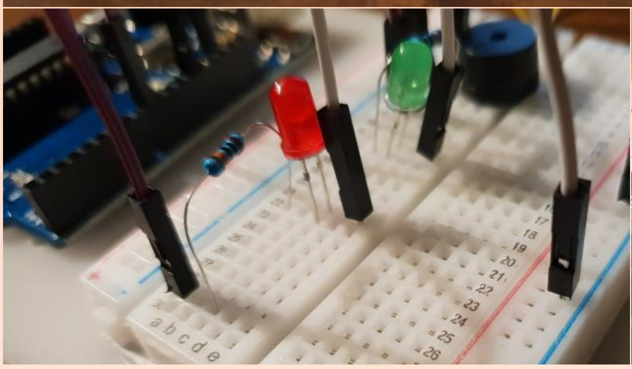
Resources: 1 buzzer, 2 LED lamps, 3 220 ohm resistors, 7 male-male wires, an Arduino and a computer

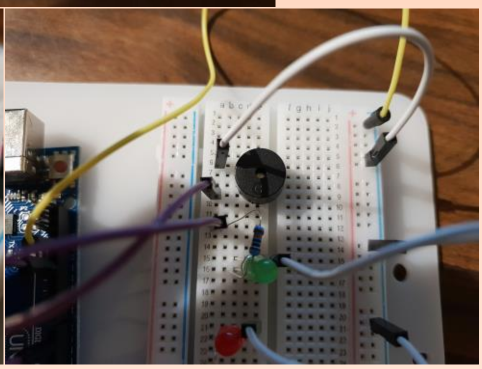
Setup:

On the Arduino we use the digital pins 12 and 6 for the lamps, 8 for the buzzer.

The red wire in the picture should be connected to the gnd of the Arduino. Make sure to use the short leg (-) of the lamps to connect to the gnd. Also connect the (-) of the buzzer to the gnd. Underneath you see an example for 1 lamp and the buzzer.







Next upload the program 'Morseplayer' onto the arduino.

Can you decode the code?

Activity 8

Let's have a closer look at the program.

In the first line you write which word you want to put into code.

```
char stringToMorseCode[] = "SOS";
```

Did you have the correct answer?

The lines underneath are used to define almost everything needed, like the pins used on the arduino, the length of a dot, the length of a dash, the length of an interval between symbols, letters and words.

```
int led12 = 12;     // blink a led on output 12
int led6 = 6;       // blink a led on output 6
int audio8 = 8;     // output audio on pin 8
int note = 1200;     // music note/pitch
int dotLen = 100;    // length of the Morse code 'dot'
int dashLen = dotLen * 3;   // length of the Morse code 'dash'
int elemPause = dotLen;  // length of the pause between elements of a character
int Spaces = dotLen * 3;    // length of the spaces between characters
int wordPause = dotLen * 7;  // length of the pause between words
```

Now change the program so that it becomes easier to distinguish the end of a symbol, letter and word. Try to program the code for 'SOS SOS'.

```
// DOT
void MorseDot()
{
  digitalWrite(led12, HIGH);    // turn the LED on
  digitalWrite(led6, HIGH);
  tone(audio8, note, dotLen); // start playing a tone
  delay(dotLen);            // hold in this position
}

// DASH
void MorseDash()
{
  digitalWrite(led12, HIGH);    // turn the LED on
  digitalWrite(led6, HIGH);
  tone(audio8, note, dashLen);  // start playing a tone
  delay(dashLen);             // hold in this position
}
```

The bit of program above defines what needs to happen at dot and dash.
By inserting // in front of the correct line you can make one light burn on dot and the other light on dash. This makes it even simpler.
// means that this is a comment, not a program part.

Finally we can also adjust the sound so that we hear one tone on dot and another tone on dash.

Which line of the program defines the pitch?
Add a line in which you define a second pitch. Name it "note1".
With dot you use "note"; with dash you use "note1".

Does it work?
Now try to decode each other's code again.
Good luck!

Maxwell

Maxwell is well known for his four laws on electromagnetism. He delivered mathematical proof for the existence of radio waves. In simple language we can summarise his important discoveries like this:

- Oscillating charges induce an electromagnetic wave that can propagate itself anywhere
- The speed of that wave is 300,000,000 m/s.
- Light is an electromagnetic wave.

Hertz

Hertz wondered how you might be able to create an electromagnetic wave.

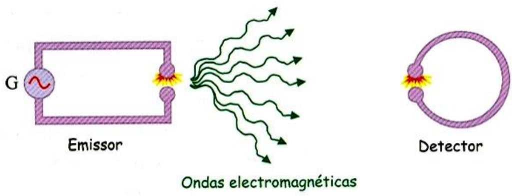
He built an oscillator that consisted of a battery to which two metal spheres were attached, with a small gap in between. The electric current caused a spark to jump from one sphere to the other at regular intervals.

If Maxwell was right and this induced electromagnetic waves, how could he see this?

He made a simple ring detector with a small spark gap.

The moment the electromagnetic wave reaches the ring detector an electric current is induced. This becomes visible as a small spark at the gap.

By moving around the ring detector in his lab and by observing the strength and shape of the spark he managed to determine the wavelength of the radiation. This proved to be almost 61m, one million times larger than the wavelength of visible light. He had discovered the radio wave.



Activity 9

Let's walk in the footsteps of Hertz and conduct his experiment.

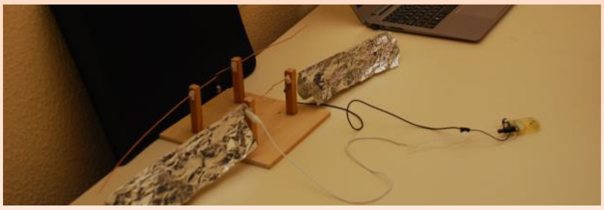
https://www.youtube.com/watch?v=9gDFll6Ge7g

Resources:

1 kitchen gas lighter, 4 copper wires, aluminium foil, 2 alligator clips, 1 neon lamp, 1 wooden board with sticks that have a gap through which you can pass a wire, black paper for background.

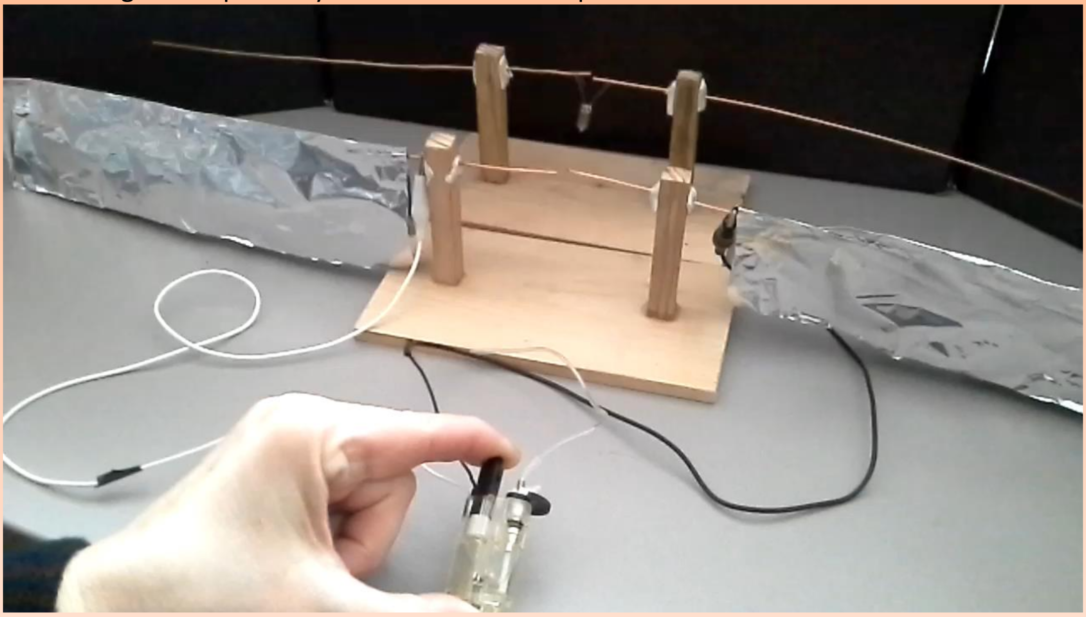
Setup:

Open the gas lighter and remove the ignition system. Use the alligator clips to attach it to the copper wires.



Experiment:

Push the igniter repeatedly and observe the lamp.

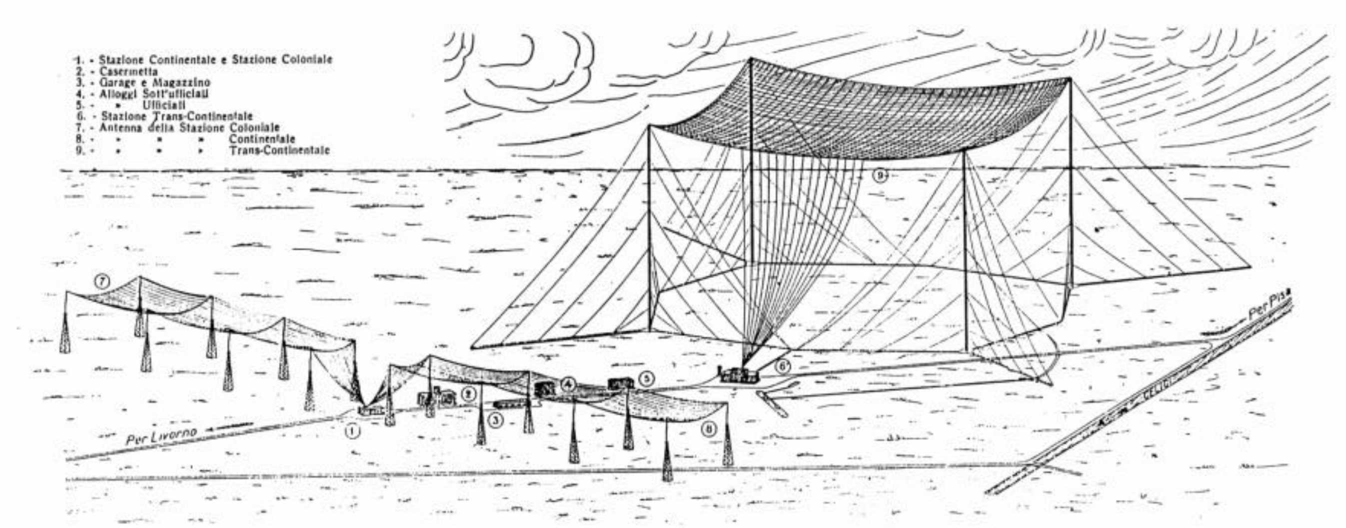


Observation: A spark is created between the first set of copper wires. The lamp burns.

Conclusion: The spark induces electromagnetic waves. These reach the other set of copper wires and induce an electric current in these copper wires which lights the lamp.

Marconi elaborated on this and developed the technology to produce and receive electromagnetic waves. He discovered that it was possible to increase the distance the waves could travel by connecting one pole of the transmitter to a wire which in turn is connected to a metal plate attached to a high post: the radio antenna. He also discovered that he could direct the waves by positioning a curved metal screen behind the antenna. In his further research he replaced the wire receiver by a magnet detector. Suddenly this allowed him to span 3,000 km. He supposed there had to be a layer in the higher atmosphere that reflected the waves. Later on this proved to be correct. This layer is called the ionosphere.

Underneath you see a drawing of the radio centre in Coltano, Italy, close to Sestri Levante. The low antennas on the front side were used for continental transmission. The high antennas for transcontinental transmission.



For radio communication we only use part of the electromagnetic spectrum.

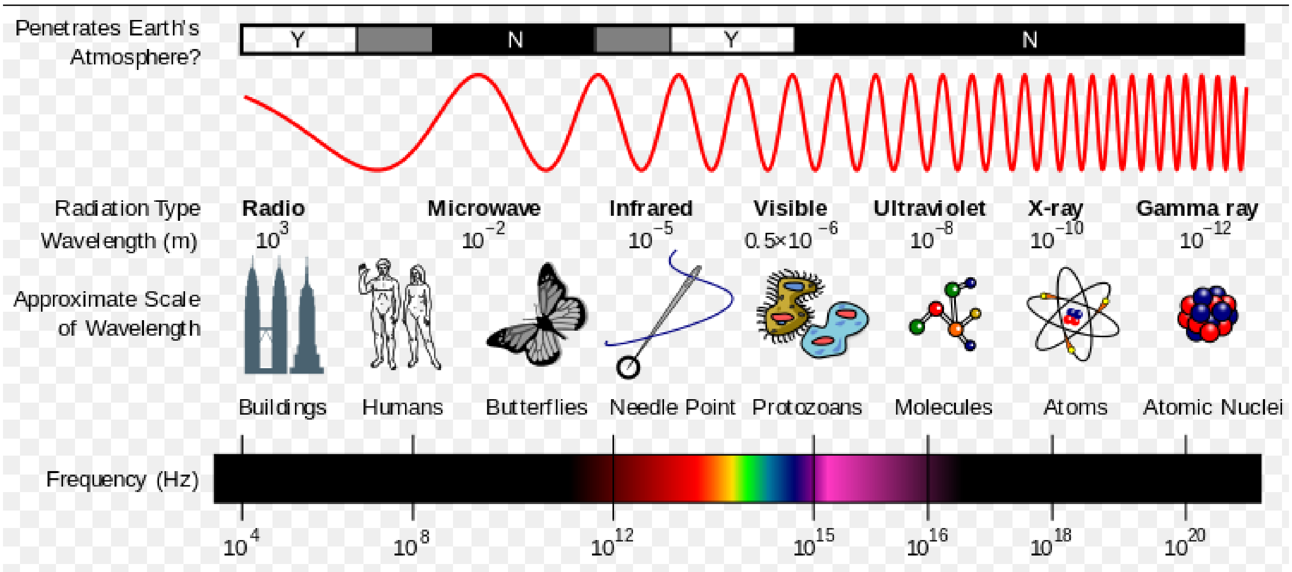
Thanks to radio amateurs in Belgium, Italy, Greece and Slovenia we could establish a radio contact between Italy, Greece, Slovenia and Belgium during our Erasmus+ project.

Belgium

Italy

The shorter waves are not used because …

- They are dangerous for the human body.
- They are difficult and expensive to produce.



Frequency band	Wavelength/m	use
Extra Low Frequency (ELF) 30 Hz – 3 kHz	>100 000	communication with submarines
Very Low Frequency (VLF) 3 kHz – 30 kHz	100000-10000	long range communications navigation and military
Low Frequency (LF) 30 kHz – 300 kHz	long waves 10000-1000	
Medium Frequency (MF) 300 kHz- 3 MHz	medium waves 1000-100	national radio
High Frequency (HF) 3 MHz – 30 MHz	short waves 100-10	national and local radio
Very High Frequency (VHF) 30 MHz-300 MHZ	ultra whort waves 10-1	international radio, radio amateur, high quality sound
Ultra High Frequency (UHF) 300 MHz -3 GHz	1-0.1	TV, air traffic guidance systems, mobile phone
Microwave frequencies > 3GHz	micro waves <0.1	telephone, satellites, radars

PART 2	
Topic	Using Morse to send signals, resulting in a work of art
Subjects	Technology - Mathematics
Level	depends on the level of mathematical questions
Aims	Students solve mathematical questions in a fun context. Students are introduced into the world of Piet Mondriaan. Students apply their knowledge of coding and decoding in Morse.
Skills	Technology : using http and email to code and decode Art : creating a Mondriaan painting Math : mathematical questions lead to answers that reveal the painting
Duration	150 min
Resources	canvas, internet, paint or markers, ruler

Introduction

These lessons will somewhat transform you into an artist, but also into a 'telegraphist'. In case radio amateurs live in your area you might even send your messages like Marconi did. Should this be impossible you can also use the website underneath.

Using https://Morsecode.scphillips.com/translator.html you can represent the Morse message in light / sound and send it through email.

This will be easier if you change the speed to 10.

A MONDRIAAN PAINTING

Activity 8

In front of you you have the grid of a painting by Piet Mondriaan, a well-known Dutch painter. Unfortunately the colour palette is missing.

Pupils in an other room or at the other side of our globe know the colour palette for your grid, but they don't have the grid.

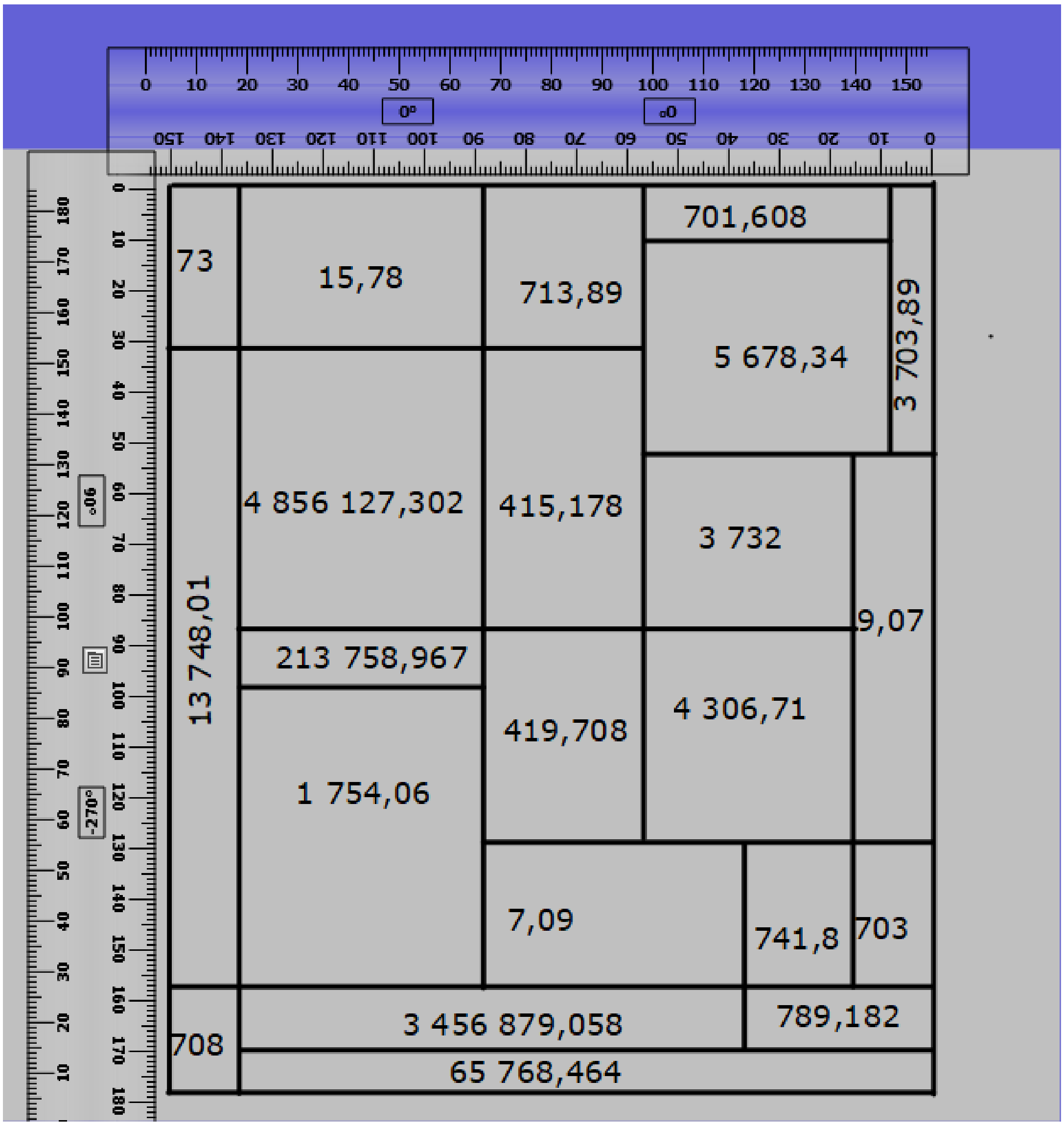
Using the Morse key they will send you the colour palette of your painting so that you know how to colour the boxes. You need to do the same thing for them.

Some of you can start drawing the grid onto the canvas. Others start coding the colour palette into Morse.

Then you try to send the first colour to the other group of pupils. And you will receive your first colour from them.

Now some of you can start colouring the boxes in which the number 7 has the value of 7 ones. First mark these boxes on the grid so that you don't add the wrong colour to the canvas.

Piet Mondriaan – Task 1



7 has a value of 7 ones (7) =

7 has a value of 7 tenths (0.7) =

7 has a value of 7 tens (70) =

7 has a value of 7 hundredths (0.07) =

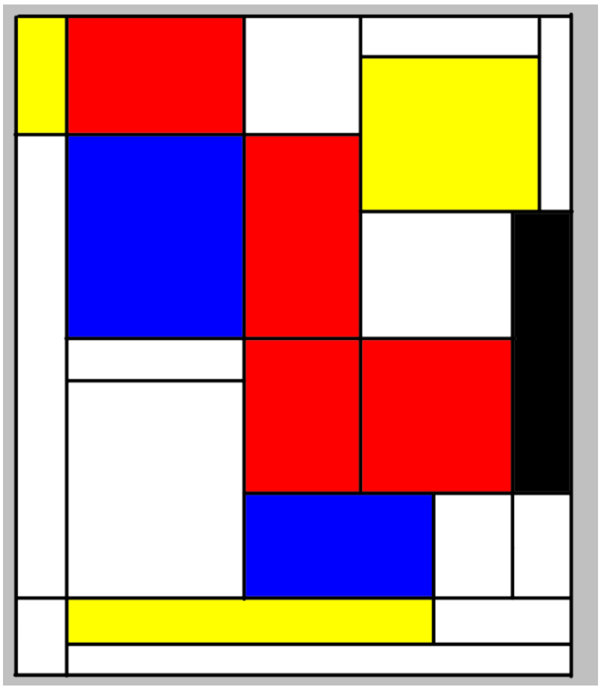
7 has a value of 7 hundreds (700) =

Piet Mondriaan – Key to task 1

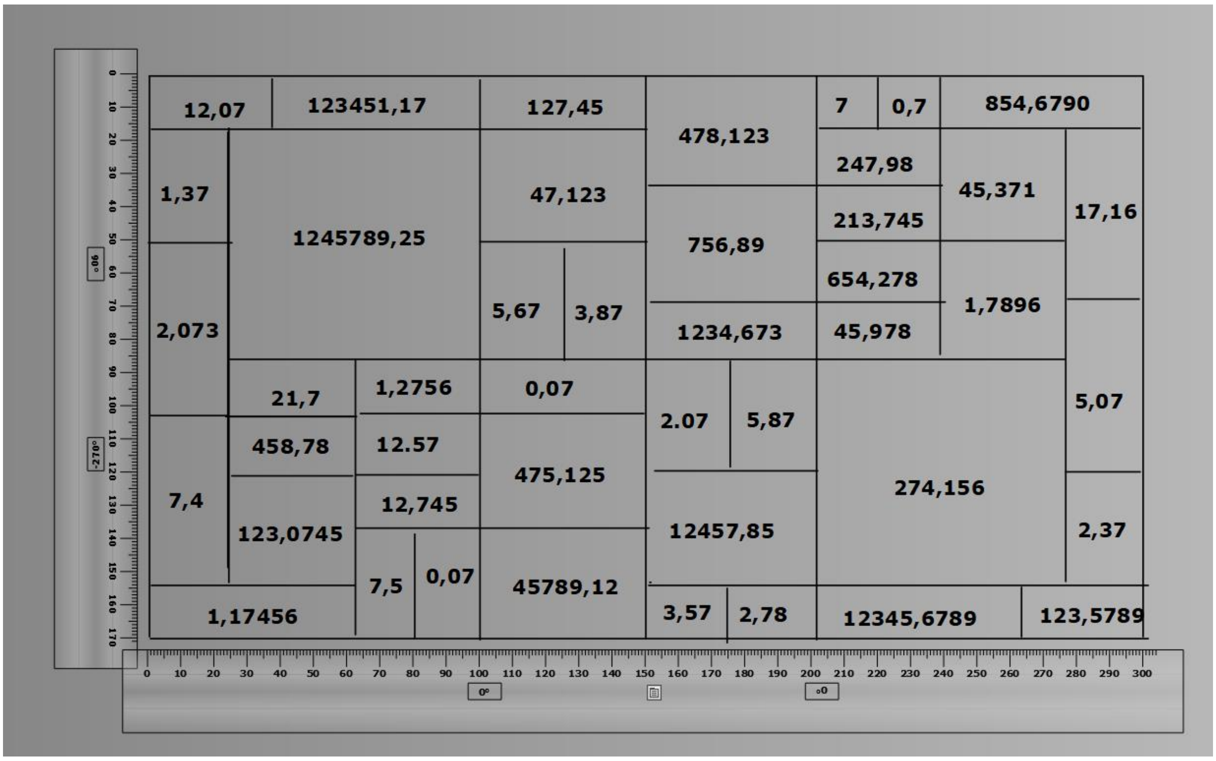
Colour the boxes into the appropriate colour.

7 has a value of 7 ones (7) = yellow
7 has a value of 7 tenths (0.7) = black
7 has a value of 7 tens (70) = blue
7 has a value of 7 hundredths (0.07) = white
7 has a value of 7 hundreds (700) = red

Piet Mondriaan – Result task 1



Piet Mondriaan – Task 2



7 has a value of 7 ones (7) =

7 has a value of 7 tenths (0.7) =

7 has a value of 7 tens (70) =

7 has a value of 7 hundredths (0.07) =

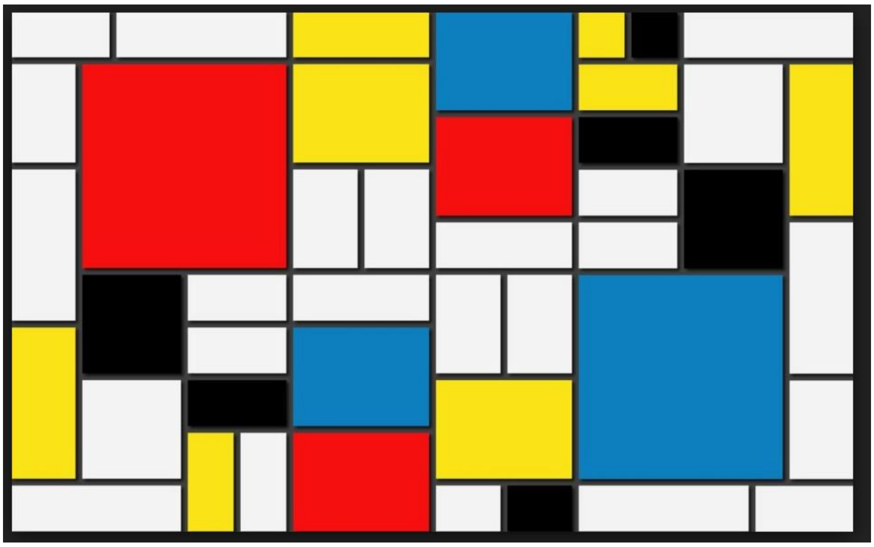
7 has a value of 7 hundreds (700) =

Piet Mondriaan – Key to task 2

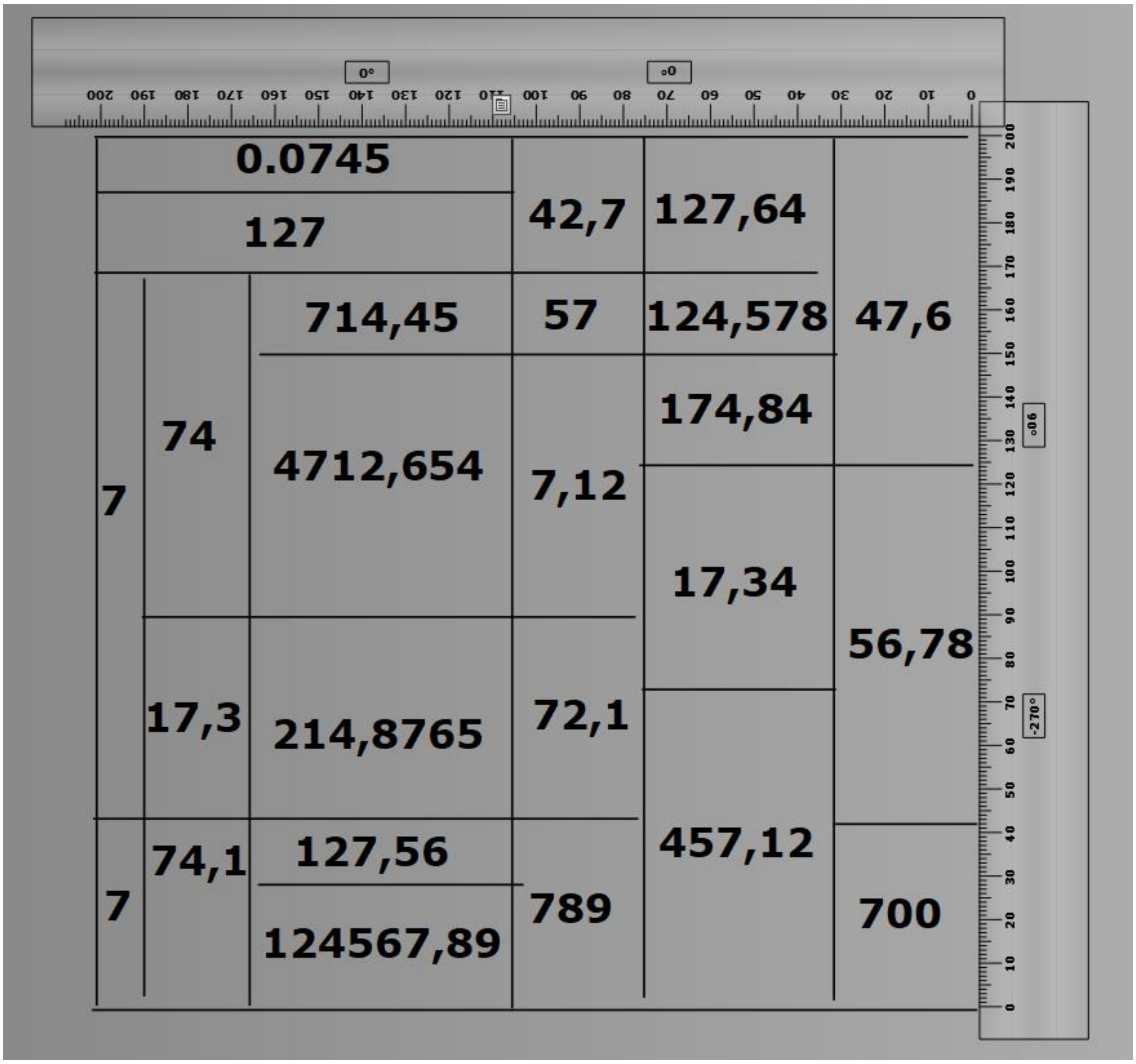
Colour the boxes into the appropriate colour.

7 has a value of 7 ones (7) = blue
7 has a value of 7 tenths (0.7) = red
7 has a value of 7 tens (70) = yellow
7 has a value of 7 hundredths (0.07) = black
7 has a value of 7 hundreds (700) = white

Piet Mondriaan – Resultaat task 2



Piet Mondriaan – Task 3



7 has a value of 7 ones (7) =

7 has a value of 7 tenths (0.7) =

7 has a value of 7 tens (70) =

7 has a value of 7 hundredths (0.07) =

7 has a value of 7 hundreds (700) =

Piet Mondriaan – Key to task 3

Colour the boxes into the appropriate colour.

7 has a value of 7 ones (7) = white

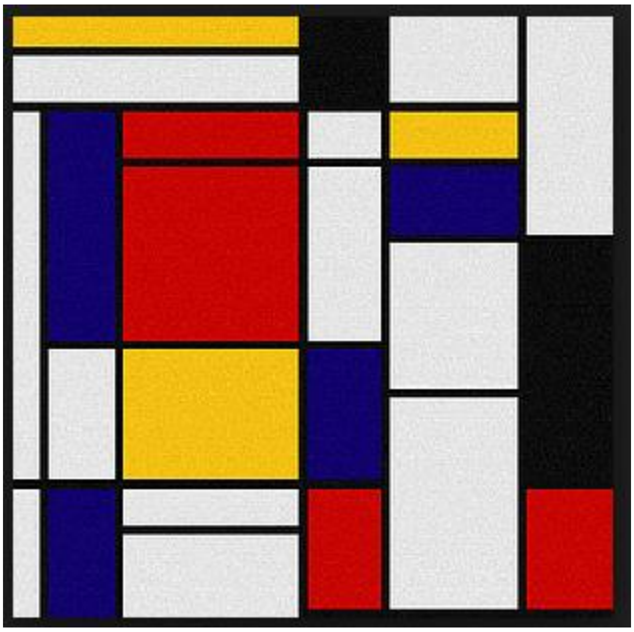
7 has a value of 7 tenths (0.7) = black

7 has a value of 7 tens (70) = blue

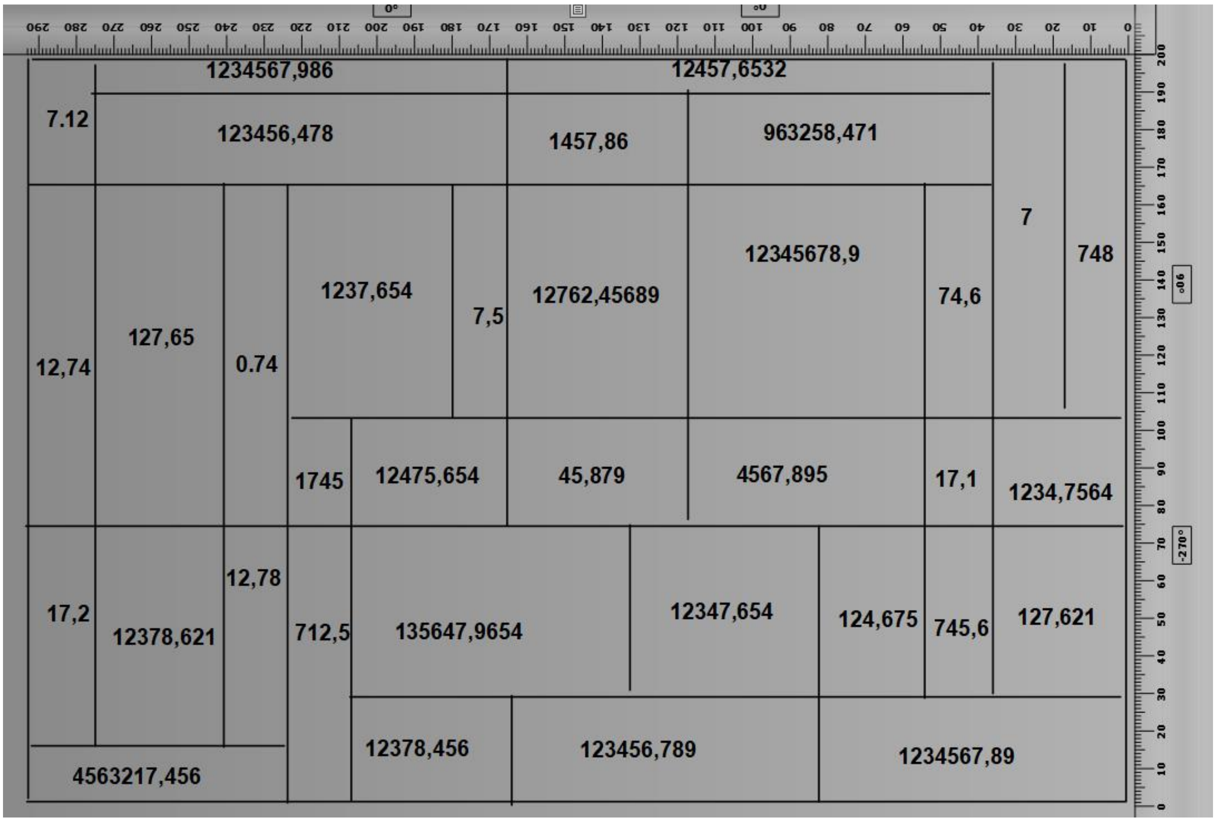
7 has a value of 7 hundredths (0.07) = yellow

7 has a value of 7 hundreds (700) = red

Piet Mondriaan : Result task 3



Piet Mondriaan – Task 4



7 has a value of 7 ones (7) =

7 has a value of 7 tenths (0.7) =

7 has a value of 7 tens (70) =

7 has a value of 7 hundredths (0.07) =

7 has a value of 7 hundreds (700) =

Piet Mondriaan – Key to task 4

Colour the boxes into the appropriate colour.

7 has a value of 7 ones (7) = white
7 has a value of 7 tenths (0.7) = black
7 has a value of 7 tens (70) = red
7 has a value of 7 hundredths (0.07) = blue
7 has a value of 7 hundreds (700) = yellow

Piet Mondriaan – Result task 4