MJSO

Malta Junior Science Olympiad

2018 | activity booklet

European Commission

HSBC Malta Foundation

DIRECTORATE FOR LEARNING AND ASSESSMENT PROGRAMMES
MEDE

Acknowledgements

The investigative task included in this Science Olympiad booklet is the result of a team effort and reflects the contributions of Ms Penelope Fitzgerald, Mr Michael Mercieca and Mr Stephen Bezzina.

Extended thanks to Ms Adriana Muscat (Senior Technical Officer) and her team of technicians for efficient lab equipment organisation and preparation.

Much appreciation to Mr Michael Mercieca (Head of School) for hosting the event at St Nicholas College Dingli Secondary School.

Special thanks are due to Mr Stephen Bezzina for the design and compilation of the final booklet version.

Table of Contents

Instructions

- **SAFETY FIRST** – wearing a lab coat together with safety specs is mandatory at all times. The immersion heater is to be handled carefully in order to avoid burns. No naked flames are to be placed near the ethanol as it is highly flammable.
- You are asked to attempt all questions and to write your answers clearly in the spaces provided. Any work scribbled on the 'Rough Work' space provided will **not** be considered.
- Each team is requested to clean the lab station adequately after handing in the script to the lab supervisor.
- It is important that all laboratory equipment is handled carefully. In case of any breakages report immediately to the lab supervisor.
- You are also reminded of the necessity of good English and orderly presentation of your answers.

Fuels are materials that produce heat energy when burned. Since ancient times humans used materials such as wood as a source of energy. By time, humans discovered other sources of energy, namely fossil fuels, that are more convenient since they provide a larger energy density. Humans' consumption and reliance on fossil fuels increased with time, such that the use of fossil fuels specifically coal, oil and gaseous hydrocarbon fuels (ex. LPG) led to the ever-growing dependence on these kinds of fuels.

Figure 1

However, fossil fuels also have a negative environmental impact. The release of carbon, in the form of carbon dioxide, which had been trapped for millions of years, is now being released into the atmosphere at an alarming rate. This leads to global warming with drastic effects on climate and weather.

Figure 2

Alternative fuels, such as ethanol, are used to provide the energy humans require. However, as a fuel, ethanol provides less energy by mass than other common fossil fuels such as diesel and petrol. Some countries like Brazil, use a mixture of petrol and ethanol in a bid to reduce the amount of carbon dioxide released into the atmosphere.

1. The production of the alcohol ethanol, is conducted by a simple fermentation process that can be processed in the school laboratory. A group of students was investigating the variables in the rates of fermentation to produce ethanol. One variable they investigated is the type of sugar used in fermentation. In their investigation, the students used two different sugars, namely glucose and sucrose.

   a. Describe the difference in structure between glucose and sucrose.

   _____

   _____

   _____ [2]

   b. Design an investigation to determine the rates of fermentation of glucose and sucrose by yeast. The following equipment is provided:

syringes; capillary tube with rubber bung; beakers; stopwatch; yeast solution; glucose solution; sucrose solution; clamp; permanent marker; white sheet of paper.

   Points to consider:

   - **Prepare the sugar - yeast solution in the ratio of 1:1 (sugar:yeast) just before drawing the mixture into the syringe.**
   - **Remove the capillary tube from the syringe and pull the mixture into the syringe. Insert the syringe back into the rubber tubing well.**
   - **Press the plunger slightly so that there is 1 cm in length of solution at the top of the capillary tubing.**
   - **Leave to acclimatise for 4 - 5 minutes before starting the stopwatch.**

Following the investigation, compile a report that includes:

i. a hypothesis of the investigation;

_____

_____

_____

_____

_____ [1]

ii. the procedure carried out;

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

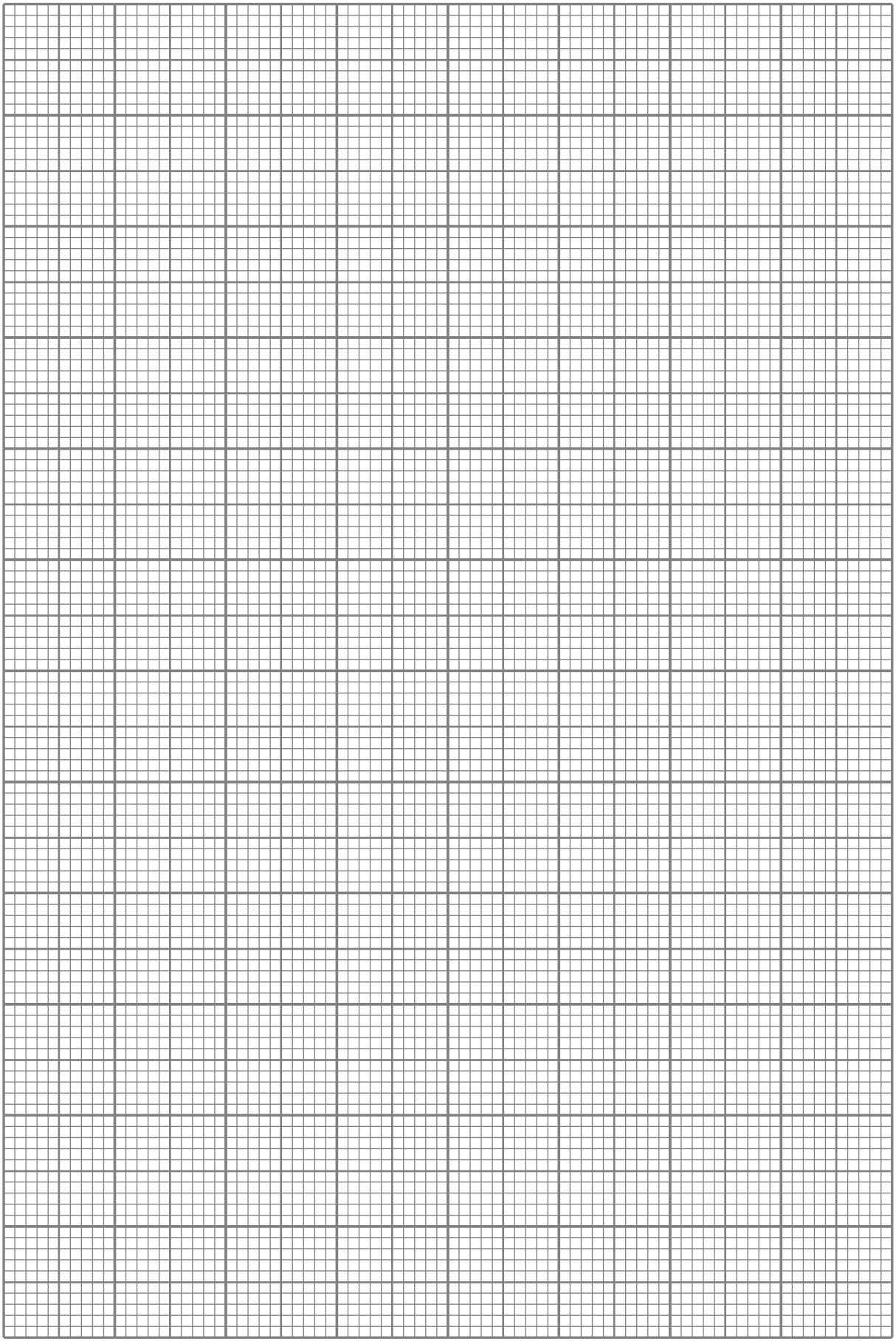
_____

_____

_____ [5]

iii. a table of results including the distance from origin of the mixture column (mm) and the time (minutes). [4]

iv. line graphs showing the average distance from origin, against time for both sugars (glucose and sucrose), on the same axes. Use the graph paper provided on the next page. [6]



v. Describe the trend shown in the results.

[2]

vi. Using your biological knowledge of sugars, explain the difference in the results obtained.

[5]

vii. Give **ONE** precaution that must be taken when conducting this investigation and justify its use.

[2]

viii. List **TWO** variables that must be kept constant during this investigation.

[2]

ix. From the line graph for glucose (drawn on page 6), calculate the rate of reaction at the fifth minute, in moles of CO_2 per minute. Assume that the working temperature in the lab is 20 °C and that the pressure in the syringe remains at atmospheric pressure for the whole duration of the experiment.

In your calculation, take the:

- internal diameter of the glass tube as 2 mm
- molar volume of gases at atmospheric pressure and 20 °C as 24,000 cm^3.

[4]

c. Summarise the process that is taking place by means of a word equation.

_____

_____

_____

_____ [1]

d. List **ONE** factor that will not allow fermentation to occur.

_____

_____

_____ [1]

2. The ethanol produced during fermentation is not pure since it is mixed with water and yeast.

a. Name the separation technique that should be used to separate yeast from the rest of the mixture.

_____ [1]

b. Perform the separation technique mentioned in part **2 (a)** on the product of fermentation provided. Use the equipment and different filtering materials available on the bench. The aim of your experiment is to determine the best filtering material. The filtering materials available include:

A. Linen
B. Muslin
C: Net
D: Filter paper

i. Draw a labelled diagram of the setup used. [2]

ii. Name the filtering material that is best suited to remove the yeast from the mixture.

_____ [1]

c. The mixture obtained from the process above contains water and ethanol. Water and ethanol mix together such that they do not form layers.

i. Write the term used for liquids that mix together.

_____ [1]

ii. Name the separation technique that separates liquids that mix together.

_____ [1]

iii. Draw a labelled diagram of the setup that would be used to perform the technique referred to in part **2 (c) (ii).** [3]

iv. Explain in detail, where and how ethanol is separated from water using this setup.

[3]

3. Draw the structural formula of ethanol. Show ALL bonds. [2]

4. Ethanol is often used as a fuel. It burns in air to produce heat energy. Using the equipment available on the bench, perform an experiment to determine the change in heat of combustion of ethanol.

   a. List the equipment used.

   _____

   _____

   _____ [2]

   b. Draw a labelled diagram to show how the equipment is set up. [3]

   c. Record your results. [3]

d. Write a balanced chemical equation for burning ethanol. Include state symbols.

[3]

e. Calculate the change in heat of combustion of ethanol in kJ/mol. The specific heat capacity of water is 4180 J/kg °C and that of copper is 385 J/kg °C.

[3]

f. Give **TWO** precautions taken to ensure more accurate results.

[2]

5. Using the apparatus given, perform an experiment to find the density of ethanol.

   a. Write down the method used, including the list of apparatus.

   _____

   _____

   _____

   _____

   _____

   _____ [5]

   b. Give **ONE** precaution necessary when performing the experiment.

   _____

   _____ [1]

   c. In the space below, record all the values obtained during this experiment. [3]

   d. Using the values obtained during this experiment, calculate the value of the density of ethanol in kg/m^3.

   _____

   _____

   _____ [3]

6. Heat energy can be transferred by conduction, convection and radiation. Different materials require different amounts of heat energy to change their temperature.

   a. Liquids are primarily heated by convection. Explain the movement of liquid particles in terms of their density in a convection current.

   _____

   _____

   _____ [2]

   b. Define the term specific heat capacity.

   _____

   _____

   _____ [1]

   Using the setup and apparatus given, perform an experiment to find the specific heat capacity of ethanol and then answer the questions that follow.

   You are requested to follow the instructions below:

   - **Pour 130 ml of ethanol into the polystyrene cup.**
   - **A note indicating the power of the heater is placed on your workbench.**
   - **Do not change the settings of the power supply - the voltage should remain set at 4 V throughout the whole experiment.**
   - **Switch on the heater for 2 minutes before dipping it in ethanol.**
   - **Handle the heater carefully in order to avoid burns.**
   - **Do not heat the ethanol for more than 5 minutes during the experiment.**
   - **Do not place any naked flames near the ethanol as it is a highly flammable material.**
   - **Once the experiment is over, switch off the heater and place it into the beaker full of water for the heater to cool down safely.**

c. Give **TWO** precautions, other than those already listed in the instructions, necessary when performing the experiment.

_____

_____

_____

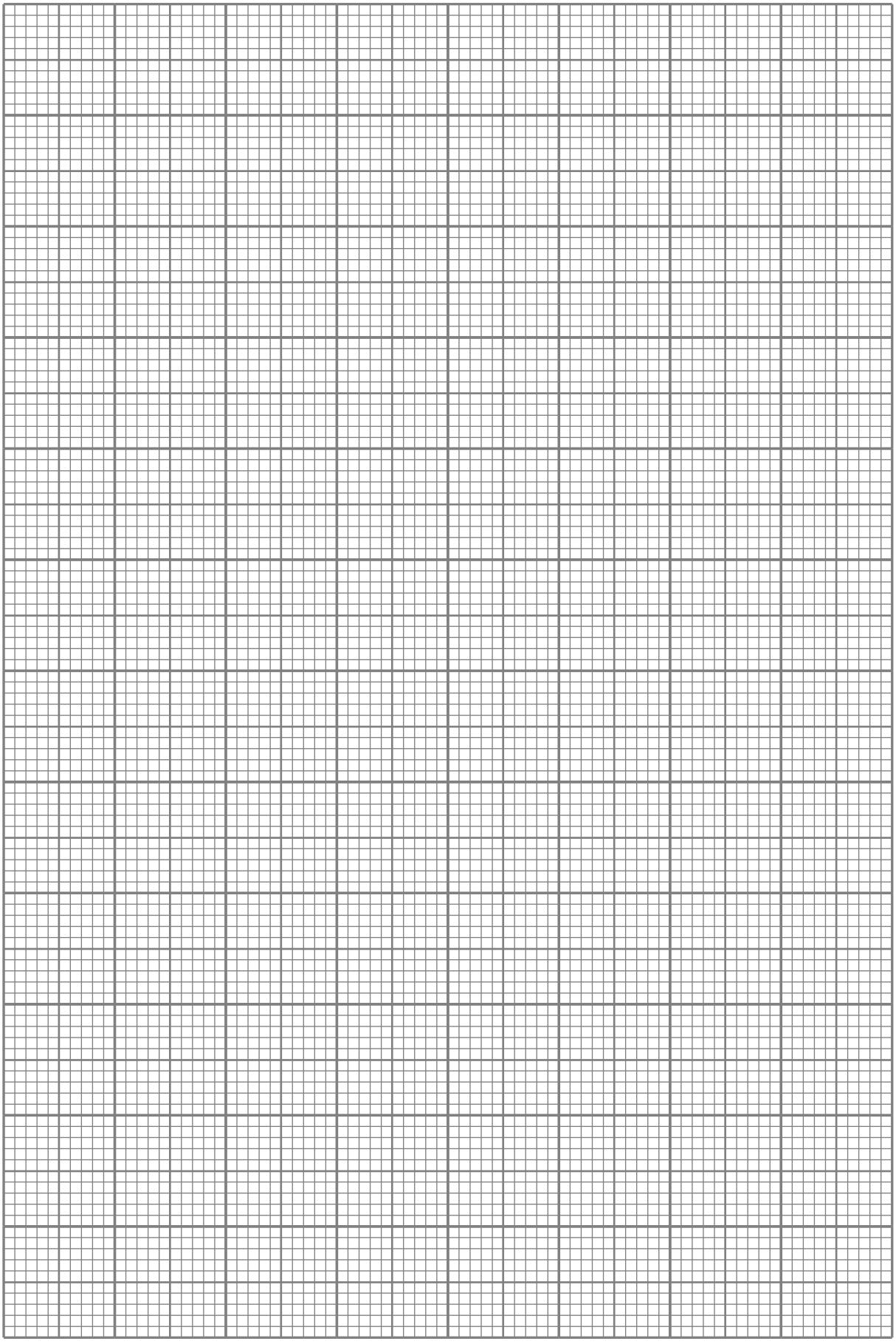
_____

_____ [2]

d. Fill in the table of results shown below with the values obtained during the experiment. [6]

Time, t (s)						
Temperature change, Δθ (°C)						

e. Plot a graph of time, t (s) against temperature change, Δθ (°C) on the graph paper provided on the next page. [4]



f. Using the graph, calculate the value of the specific heat capacity for ethanol. Show all your working in the space below.

[6]

g. The specific heat capacity of water is larger than that of ethanol. Explain this difference in terms of the amount of heat energy required and the time taken to heat ethanol when compared to heating the same mass of water.

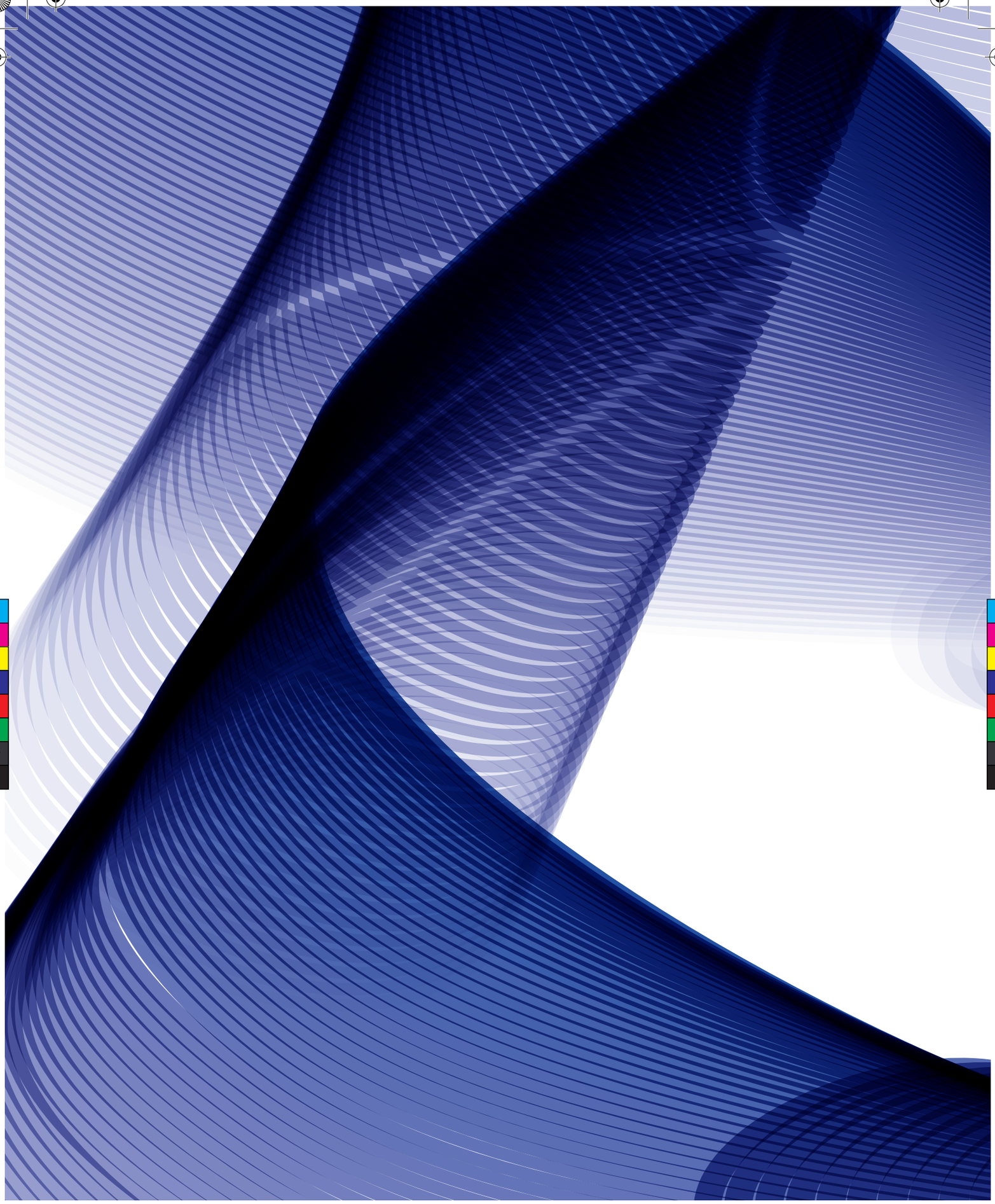
[2]

SPACE FOR ROUGH WORK

SPACE FOR ROUGH WORK

SPACE FOR ROUGH WORK

SPACE FOR ROUGH WORK



European Commission

HSBC Malta Foundation

DIRECTORATE FOR LEARNING AND ASSESSMENT PROGRAMMES
MEDE