Title: Car Painting

Topic: Students explore through various interdisciplinary activities the mathematics and science topics involved in the car painting process, and make decisions on car paint.	**Time**: 5 x 45 min lessons	**Age**: Grade 6-9, 12-15 year olds

Differentiation

Lower level

The basic outcome of pupils is to develop an understanding of the car painting process, and the thickness of the car paint. They can also work with 2D shapes to calculate the paint needed for a car's surface.

Higher level

In addition, students can develop an understanding of the process used in car painting (electrostatic charge) and develop 3D models for calculating the paint needed for a car.

Guidelines, ICT support etc.

- Problem / Key question: A car company production manager is concerned about the quality of the cars' paint, since quite often customers complain about the quality and durability of the car paint. *Are there any flaws in the car painting process*?
- Students work in groups to answer the key question and provide the manager with useful information on how to improve the painting process.
- Two videos can be used to introduce students in the 'world' of car painting process.
  https://www.youtube.com/watch?v=alk1dfiPI7c
  https://www.youtube.com/watch?v=otOYaIFgiTo
- Pupils work in groups of 3-4.
- Students can use Geogebra software to calculate the surface of various irregular polygons, or just use regular shapes to calculate car's surface.
- Students could also use spreadsheets (or calculators) in their calculations.

Equipment needed for this activity

- worksheets for students
- computers with internet connection
- computers equipped with the GeoGebra software (software can be retrieved/or used for free from www.geogebra.org)

Required knowledge:

- elementary arithmetic operations
- surface area of regular shapes (square, triangle, rectangle)
- scale

Health and Safety:
No special requirements

Learning outcomes for this activity
All:

All students are expected to understand the core problem situation (special process of painting a car, different views of a car). It is also expected that all students will gain an understanding of how the different views of the car are related to each other.

Most:

Most students are expected to gain a full understanding of the various processes (different layers, calculation of the surface area of a car) and be able to create an appropriate model for solving the problem.

Students are also expected to be able to use/connect the various 2D shapes provided for measuring the car's surface.

Some:

Some students are expected to be able to understand teh scientific process (electrostatic charge) of painting a car, and to transfer the model for measuring the car shape from 2D to 3D, using the provided tools.

Lesson description

Starter Activity

During the first part of the activity students can work individually to read the provided introductory text and answer the readiness questions (Worksheet 1). The purpose of this starter activity is to introduce students to the context of the problem, and to familiarize themselves with the problem setting, and the various concepts and units of measurement provided.

Main Activity

Students form groups of three to four. During the main activities (Worksheets 2, 3, 4) students work in their groups to solve the problem. However, each student is provided with his/her own worksheets. Each group works on the problem under the supervision of the mathematics and science teacher. Appropriate feedback and support (to overcome difficulties) is provided when needed.

In the second activity (Worksheet 2) students work in developing an understanding of the car paint thickness, and in making connections between the different units of measurement (mils, microns, meters). They also link the thickness of the paint to various common items (e.g., paper sheet). In activity 3 (Worksheet 3) students also work in groups, trying to develop an understanding of the process used in car painting (electrostatic charge), and to identify other situations in which the process is used.

In activity 4 (Worksheet 4) students are encouraged to work in Geogebra (or in their worksheets if preferred) in developing a model for calculating the surface area of a car. Students have to link the different 2D images in understanding a 3D model of a car, while they also have to use the scale provided in calculating the actual car's surface.

During the last part of the activity (Worksheet 5) students prepare their letter, on an individual basis, addressing the main key-findings of their work.

Plenary

A whole class discussion takes place. Each group presents their results for discussion and reflection. The teacher orchestrates a discussion that focuses on the core scientific concepts (electrostatic charge), spatial reasoning and mathematical concepts and processes (e.g., proportional reasoning), used in solving the problem, and provides guidelines for further improving the students' solutions.

Car Painting

Work sheet 1

The manager of a car painting company is concerned because some of his clients make complaints that car painting is too expensive. He is also concerned that perhaps the system used might use a lot more paint that is actually needed for painting a car. Taking into consideration that the price of paint has been increased a lot during the past few months, there is a strong necessity to reduce the cost for painting new cars.

When asked by a local newspaper reported, the manager said: "Paint is more complex and precisely engineered than is often appreciated. Automotive paint has been engineered to withstand: Fading by sunlight, impact from stones and road chippings, damage from rain, oil and petrol, and damage from car washing."

The paint often consists of five different layers - each chosen to give a precise function. The paint typically consists of:

- a galvanized steel substrate with a thin crystalline tri-cation phosphate treatment to enhance adhesion and improve corrosion protection;
- a ~25μm electro-coat is then added which is the first protective layer. Lower panels have an antichip layer, which is a thick layer designed to give protection against impact from stones;
- a primer layer (~25μm), a basecoat layer (which is the colour layer, thickness ~25μm) and a clearcoat (50μm).

For second hand cars, there are many steps required in re-painting a car. At first someone has to cover all parts that will not be painted. Next we need to sand down the old paint, using fine sandpaper. We also may need to use coarser paper for removing rust or excess fillers. We then apply several thin coats of quality filler, and we finally paint the car.

While painting the car, we overlap the spray pattern 33% to 75% of the previous pass, and use medium wet coats that look smooth and glossy. The paint's thickness (coat and paint) should be between 6-8 mils (1000 mils equal to 1 inch)."

Answer the following questions

a. Which problems does the car company manager face?

……

……

……

……

……

b. Which are the five layers of a car paint? What is the purpose for each of them?

……

……

……

……

……

c. How thick is the car paint? How much thicker a piece of paper is, compared to the thickness of a car paint?

……

……

……

……

……

……

……

……

Car Paint Thickness

Work sheet 2

The typical thicknesses of the car paint layers are:
Primer: 0.3 - 1.5 mils
Base (colour) coat: .5 - 1.5 mils
Specialty coats (optional): .3 - .8 mils
Clear coat: 1.5 - 4 mils

How thick is a mil exactly?
A mil is a standard unit of measurement meaning one thousandth of an inch, or .001 of an inch. In other words, it would take 1000 mils to make an inch.

Task 1:

Calculate the total thickness of car paint in mils and in meters (you can also use microns (a metric unit of measure meaning 1 millionth of a meter).

Task 2:
How thick are standard items around the classroom (sheet of paper, hard cover, ruler), compared to the clear coat found on most vehicles?

……..

……..

……..

……..

……..

Car Paint Engineering

Work sheet 3

Electrostatic charge is used in paint spraying. The paint is sprayed onto the car bodies and the process is made more efficient by using electrostatic charge. The paint spray goes past a high voltage positive needle as it leaves the spray gun and the tiny droplets of paint pick up a positive charge. They do this by losing negative electrons. It is only the electrons which can move.

The car body is then given a high voltage negative charge which attracts the positively charged paint droplets.

Normal spray gun uncharged paint droplets

Electrostatic spray gun charged paint droplets

This improves efficiency, since (a)the paint droplets spread out more as they leave the gun, and (b) the paint droplets are attracted to the negative metal car body, and so less paint will be wasted by landing on the floor or the walls of the paint shop.

Task 1:

List the reasons why electrostatic charge is used in car painting?

……

……

……

……

Task 2:

Search the internet to find other applications of the electrostatic charge method.

……

……

……

……

Car Painting

Work sheet 4

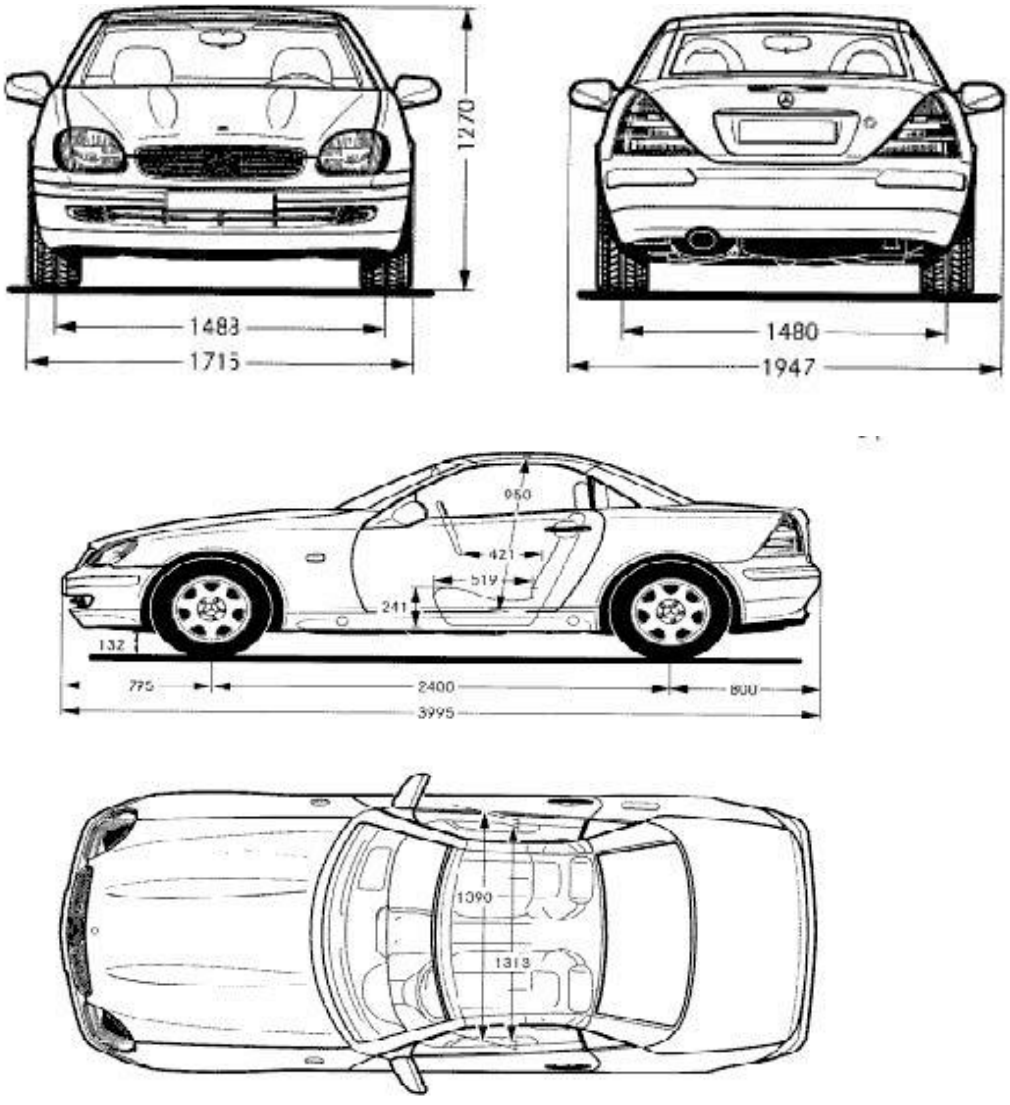
Task 1:

Below are the layouts of two sport cars that need to be paint.

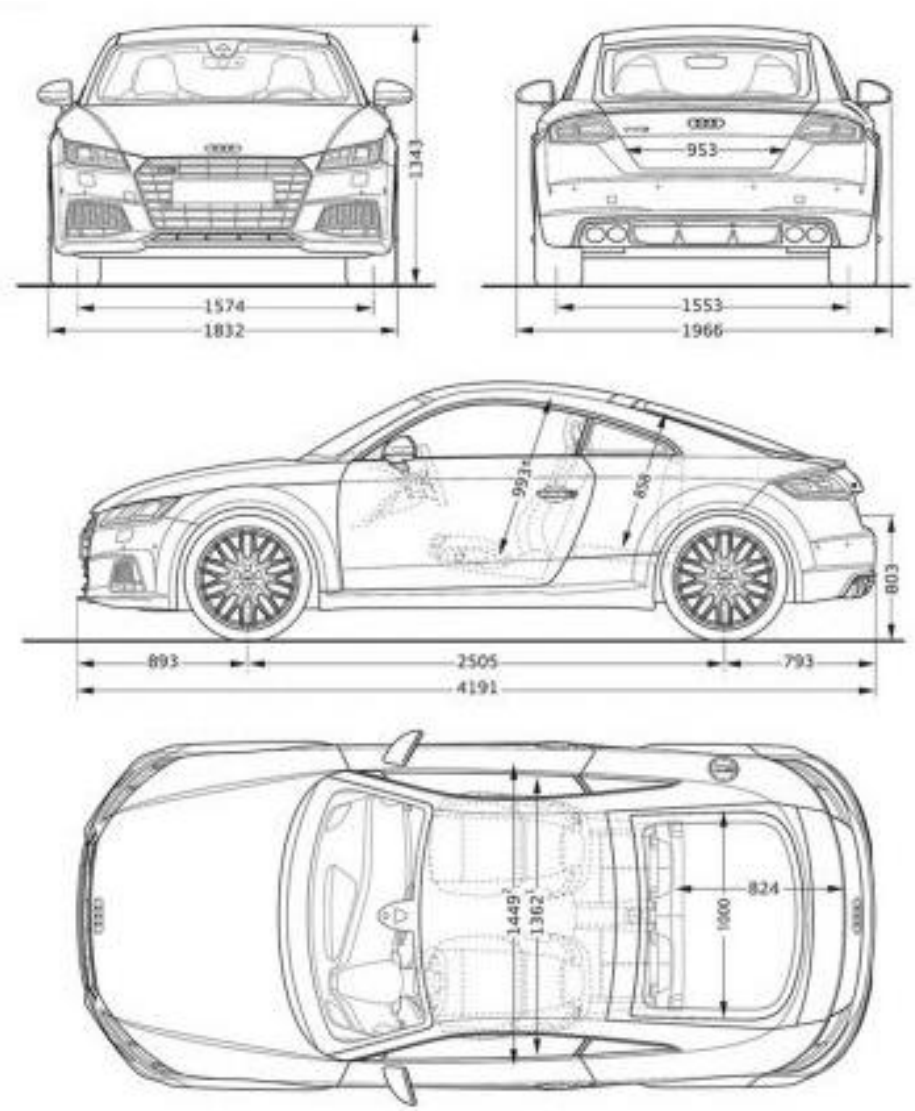
Please select one of the two cars. Then use the various diagrams to estimate the surface area of the car that has to be paint (Note the dimensions! Could you think of the unit?)

You can also import the diagrams into GeoGebra and measure/ calculate the area using the software's tools.

Car A



Car B


1343
953
1574
1832
1553
1966
993
658
803
893
2505
793
4191
1449
1362
824
1600

Task 2:

Calculate how much paint is needed for this car, if the thickness of the paint is 10 mils.

Task 3:

Based on your results in Task 2, what is the maximum amount of paint that is needed for painting 100 cars? (you may also think of the amount of paint that is wasted during the work!)

Car Painting

Work sheet 5

Write a letter to the Car Company Manager, explaining how your team worked in solving this problem. In your letter you should make explicit how your team used your knowledge from plane and 3D geometry, and algebra in solving the problem!

Dear Manager,

Our team, _____, worked in the following way to calculate how much paint is needed for painting a car: