Title: Aviation – De-icing an aircraft

Topics: surface and volume, proportions, weight, density, freezing point of liquids	**Time**: 90 minutes	**Age**: 13-14

Differentiation:

Higher level: chemical processes of lowering the melting point of ice can be discussed

Lower level: Modelling airplane surface with geometric figures on work sheet 1 can be simplified

Guidelines, ICT support etc.:

It is suggested that this unit is done in team-teaching between a mathematics teacher and a chemistry teacher.

If possible, a model plane can be brought into the lesson to demonstrate the different areas that can be covered with ice on the model instead of on the diagram

Equipment needed for this activity:

Work sheets

Optional: Model plane

Optional: Computer with GeoGebra software

Required knowledge:

Calculation of surface of a cylinder

Concepts of mass and density

Concepts of modifying freezing point of liquids

Mixing of chemicals

Health and Safety:

Learning outcomes for this activity:

Students should be able to understand the need for de-icing an aircraft

Students should be able to model and calculate or estimate the surface area of complex objects

Students should be able to calculate the weight of ice or snow on an aircraft

Students should be able to name advantages and disadvantages of different de-icing fluids and other de-icing methods

Lesson description

Starter Activity

Begin either with open question round: “Who has already flown”, “who has observed the de-icing of an aircraft”, “why you think that is necessary” etc. Alternatively, the unit can be started with showing a video of de-icing.

Main Activity

Students form pairs and/or groups of three. Each group receives work sheet 1 and works on it under the supervision of the mathematics teacher. This is followed by a short comparison of results. Pairs/groups then receive work sheet 2 and work under the supervision of the chemistry teacher. This is followed again by a comparison of results.

Plenary Activity

The question sheet is used by the maths and chemistry teacher in plenary session to close the topic with common-sense questions. It can be projected on a screen or whiteboard.

Aviation – De-icing an aircraft

Work sheet 1

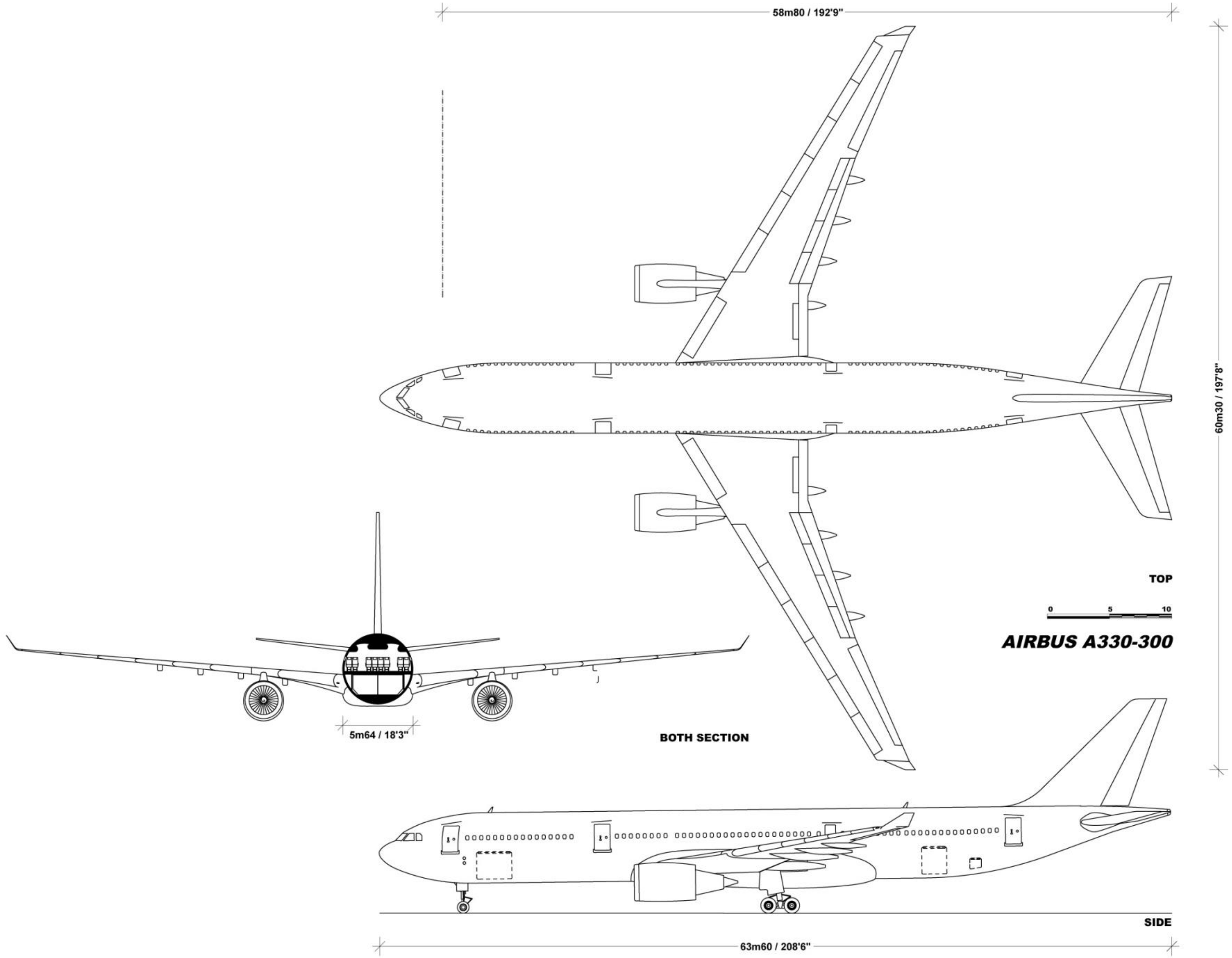
Scenes like the one above can be observed at most airports in winter time. Airplanes are de-iced, i.e. the layer of ice (and occasionally snow) is removed from the planes' wings (and sometimes rudders or other steering elements), usually with the help of a chemical substance. But why is it necessary to de-ice an airplane in the first place?

Task 1: Below is the layout of an Airbus 330-300. Use the diagram to estimate the wing area (you can also import the diagram into GeoGebra and measure the wing size there), and the total surface area of the plane (you can assume the main body of the plane to be a cylinder; don't forget to add the underside of the wings).

Task 2: How heavy would a 5 cm layer of snow (the density of new snow is approximately 100 kg/m^3) be that covers both wings?

Task 3: In cold weather, the whole plane may be covered by an ice layer. Suppose this layer has a thickness of 1 mm. Make a guess how heavy this layer is, then use the results from Task 1 and calculate the weight of the ice layer (the standard density of ice is 916.7 kg/m^3).

Remark: The main danger does however not so much come from the weight of the ice, but from it negatively influencing the aerodynamic properties of the plane. A thin ice layer of 0.1 mm on the wings can reduce the lift of the wings by 30 %!


58m80 / 192'9"
60m30 / 197'8"
TOP
0
5
10
AIRBUS A330-300
5m64 / 18'3"
BOTH SECTION
SIDE
63m60 / 208'6"

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Work sheet 2

De-icing of commercial airplanes on the ground is mainly done with a chemical substance. Four types of chemicals are usually used. They are all mixtures of water, glycol (usually ethylene glycol or propylene glycol), and eventually a thickening agent, in different proportions. Technically there is a distinction between de-icing (removing ice that's already there) and anti-icing (prevention of build-up of new ice), and Type 1 is mostly used for de-icing only, while the other three types can be used for both de- and anti-icing.

Task 1: Find out the freezing temperature of a mixture of 20 % water and 80 % propylene glycol. This would be a typical Type I de-icing fluid. It has a low viscosity and is therefore mainly used for de-icing (removing ice that's already there).

Task 2: A typical Type IV de-icing fluid consists of approx. 49 % water, 50 % glycol, and 1 % thickening agent plus some other chemicals. What would be the freezing point of such a mixture (you can ignore the 1 % thickener and other chemicals)?

Task 3: The chemical mixture described in Task 2 provides very good protection from new ice to build on the wings (it has a long *holdover time*). Why do you think this mixture is not always used despite its good protection properties?

Task 4: Why does a 60:40-mixture of glycol (freezing point –12 °C) and water (freezing point 0 °C) have a lower freezing point (–45 °C) than both fluids?

Remark: While in the air, most aircraft wings are de-iced by electrical de-icing (at propeller planes) or thermal de-icing (at jet planes; this uses hot air from the jet engines which streams through hollow channels of the wings). Electrical de-icing is very energy-demanding and hence very rarely used for de-icing on the ground. Thermal de-icing cannot be used on the ground, because the wings would overheat (no airstream to cool them down).

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Question sheet

Some questions to round up the lesson and start a discussion.

Question 1: Do you think de-icing is sometimes done with only hot water? When would you do that, and why?

Question 2: Why is the usual street de-icing agent – salt – not used more frequently?

Question 3: Suppose a plane is half the size (half the width and half the length) of the Airbus 330-300 from work sheet 1. It is covered by the same 1 mm ice layer. Would this layer be half as heavy, double as heavy or a quarter as heavy as the one in Task 3 of work sheet 1?

Question 4: Do you think they use the same de-icing fluids for de-icing the runway?

Question 5: The de-icing fluids (mixtures of glycol and water) are not always used pure, but mixed with further water. Why would you want to do that?