

# CONTENTS

	<b>Page</b>
<b>PREFACE</b>	<b>3</b>
<b>INTRODUCTION TO DISTANCE LEARNING</b>	<b>4</b>
<b>MODULE OBJECTIVES</b>	<b>7</b>
<b>SECTION A – WHY SURFACE FINISHING</b>	
Lesson 1 Surface Finishing Techniques and Application	
Lesson 2 Properties of Different Surface Finishes	
<b>SECTION B – GENERAL PRINCIPLES OF ELECTROPLATING</b>	
Lesson 3 Why Electroplating is Used as a Coating Method	
Lesson 4 Basic Electroplating Circuits and Calculations	
<b>SECTION C - CHEMICAL REACTIONS AT ELECTRODE SURFACES</b>	
Lesson 5 Chemical Symbols and Chemical Equations	
Lesson 6 Electrode Reactions in Electroplating	
Lesson 7 Electrode Reactions and Faraday's Laws	
Lesson 8 Electrode Reactions and Deposition Rate	
<b>SECTION D - CARE AND MAINTENANCE OF SOLUTIONS AND PRODUCT QUALITY</b>	
Lesson 9 The Physical and chemical Properties of Electroplating Solutions	
Lesson 10 The Structure of Electrodeposits	
Lesson 11 Testing Electroplated Coatings	
Lesson 12 Process Control and the Hull Cell	
<b>SECTION E - INTRODUCTION TO CORROSION</b>	
Lesson 13 How Coatings Can Prevent Corrosion	
<b>SECTION F ANODISING</b>	
Lesson 14 The Principles of Anodising	
Lesson 15 - The Anodising of Aluminium	

## **SECTION G SERVICES**

Lesson 16 - Water chemistry, Utilities and Prime Services

## **SECTION H - HEALTH, SAFETY AND ENVIRONMENTAL ISSUES IN SURFACE FINISHING**

Lesson 17 Health, Safety and Environmental Legislation

Lesson 18 Health and Safety Hazards and Precautions

Lesson 19 The Treatment and Disposal of Metal Finishing Wastes

**APPENDIX 1 Self Marked Assignments**

**APPENDIX 2 Marked Assignments**

**APPENDIX 3 Glossary of Terms**

**APPENDIX 4 Examination Regulations**

## PREFACE

This distance learning module is based on the notes for the tutored course module that has been offered for several years by the Institute of Materials Finishing.

Changes and additions have been made to the original notes to take into account the various technical innovations that have taken place in more recent years and, in particular, the changes in environmental, health & safety practices and general changes in industrial working.

One major change has been to ensure that study by distance learning mirrors the course offered by the tutored route. The Objective Syllabus for both paths is now identical and the courses are examined in the same way, both leading to the same qualification and certification.

The Institute appreciates the hard work in carrying out this revision by Clive Barnes and Trevor Crichton. Further, thanks are expressed to all those other members of the Institute who have contributed by way of offering advice, reading of revised lessons etc.

# INTRODUCTION TO DISTANCE LEARNING AND THIS MODULE

Distance Learning differs from the traditional method of learning that you will have used at school or college, where you work at a fixed rate that is determined by your teacher or lecturer. Their rate of teaching may be too fast or too slow for different students, so you either get bored or cannot keep up. Furthermore, if you miss a lesson, you will have to catch up before the next lesson, or you will quickly fall behind.

Distance Learning is not a new concept and has been around for several decades and it allows you to work at your own pace and in your own time. The Institute of Materials Finishing has been offering their courses for many years and after listening to our students, we realised that the preferred method of teaching was by offering scripted lecture notes.

Although you will be often working alone in your studies, the Institute makes sure that you have enough support if and when you have any problems.

In this latest revision of our courses, each lesson is a self contained and complete unit. This 2010 revision has also reviewed the course content to make it more applicable to the modern surface finishing and surface engineering industry and has allowed us to include new and recently introduced technologies.

As you are aware, you have been allocated an 'Industrial Counsellor' who, hopefully, is a member of your company. One of the roles of the Industrial Counsellor is to help you understand what you are being taught. We fully accept that no-one will fully understand every part of their course the first time they see it. Every person is different and has different skills and attributes, so they will find different parts of the course either easy or more difficult. When you meet a difficulty, you should ask the Industrial Counsellor to help you; it is their role to help you to understand the content of the lessons. If a suitable person is not immediately available within your company then the Institute will have made arrangements for you to be linked to a suitable local member of the Institute who has agreed to be available to assist you. Even if this person cannot immediately answer your problem, he or she will know someone who can. Most importantly, do not become disheartened in your studies. If, on any occasion, your Counsellor is unable to help, you should contact the Education Manager at The IMF's Head Office who will arrange for a Professional Member to contact and assist you.

You will find it very useful to have a pencil or pen and paper with you when you are studying, as you can quickly write down any extra notes or explanations; these can be very useful when you come to revising or are seeking further help.

This module is made up from a set of lessons of various lengths that are composed of written text with some illustrations where relevant. You may need to read the text several times to fully understand it and before moving on to the next lesson.

There is a series of different tasks set throughout the text; these are headed SAQs, SMAs and MAs.

# Institute of Materials Finishing

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## SAOs - Self Answered Questions

SAQ's are questions relating to what you have just studied. Their purpose is to check that you have understood the lesson so far. Firstly, you should try to answer the question without checking back through your notes and then check your answer with the model answer provided at the end of the Lesson. If your answer is correct, you should continue with the next part of the lesson. If, however, you are unable to answer the question or have incorrectly answered the question, we suggest you go over the section again and get a better understanding of the lesson.

## SMA – Self Marked Assessment

SMA's are usually found at the end of a lesson, but by no means every lesson. They are a series of questions that you should try to answer. The questions will be relevant to the lessons that you have just studied and there will be four or five possible answers for each question. You should identify which one you think is correct and when you have completed the series of questions, you should check your answers against those given at the end of the lesson. You will also find a short explanation explaining why each answer is correct or incorrect.

These SMAs, as both questions and answers, are also included in Appendix 1 and can be a useful source of revision prior to your examination.

## MA –Marked Assignment

You will be expected to carry out a series of 4 assignments during your studies. These will cover some of the Module's objectives and are designed to test your understanding of the study material and that you can use the knowledge gained to suggest answers to specific problems or situations. In the traditional system of learning, this may have been called 'homework'.

You will find detailed instructions on how to carry out the assignments in Appendix 2. Please pay particular attention to the information regarding **plagiarism** and make sure you fully understand it and the consequences of plagiarism

After completing each assignment, it should be sent to the Institute to be externally marked. (NOTE Students on tutored courses will have their assignments marked by their tutor.) Once marked, it will be returned to you. The total marks you receive for the four assignments contribute up to a maximum of 20% towards your final examination mark, so you are rewarded for your efforts.

**Please note: marked assignments are compulsory and must be submitted by the due date for you to be eligible for the final examination. This is fully explained in Appendix 2 and Appendix 5.**

## The Examination

Your examination will last for 2 hours and the examination paper consists of two sections:

**Section A** 5 short essay questions, all of which should be attempted, for which it is

# Institute of Materials Finishing

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suggested you should allow about 30 minutes in total for your 5 answers.

**Section B** consists of 8 longer essay questions, of which you should attempt five; it is suggested that you allow about 15 minutes for each answer.

Section A gives a maximum of 25% of your total marks and Section B gives 75% of your total marks for the examination. Your answer papers will be marked by an external examiner of the Institute and the examiner's mark will be moderated by the Institute's Examination and Qualifications Board (EQB).

The pass mark is 40%. This is made up from both your marks for your MA's as well as the marks you obtain in the final examination.

A mark of 60% and over gives a '**Pass with Merit**' whilst a mark of over 75% gives a '**Pass with Distinction**'. If you achieve these marks, the credit will be shown on your certificate. (An average mark of at least 40% must be obtained for the 4 assignments for a merit or distinction to be awarded)

**NOTE:** Candidates whose first language is not english may use a dictionary book during the examination, other types of dictionary, e.g. electronic ones and technical dictionaries, are not permitted. The examination's invigilator will check that the dictionary is suitable before the start of the examination. (Examples of suitable dictionaries are standard english dictionaries and dictionaries providing translation from english to another language and vice versa.)

## Additional Distance Learning Modules

There are additional modules of a similar academic standard. These are:

- Electroplating Practice
- Powder Coating
- Environmental, Health and Safety
- Paint, Lacquer & Varnish OR Automotive Surface Finishing
- Materials Science
- Electroforming

Any one of the above, combined with the module you have just completed, can lead to the award of a '**Technician Certificate**'. The benefit here is that you can apply for the professional qualification '**Technician of the Institute of Materials Finishing**' and the **insignia TechIMF**, with which you can apply for the international award from the UK Engineering Council of '**Engineering Technician**' and the insignia **EngTech**, which is internationally recognised across all industries.

# OBJECTIVE SYLLABUS FOR PRINCIPLES OF ELECTROPLATING MODULE

## **SECTION A - Why Surface Finishing?**

### **Lesson 1 - Surface Finishing Techniques and Applications**

**At the end of Lesson 1, you should be able to:**

- 1.1 Define surface finishing.
- 1.2 Describe the main processes used for Surface Finishing and their basic principles.
- 1.3 Describe the purposes for which these finishes are applied to substrates.
- 1.4 Describe the nature of the Surface Finishing Industry and its economic importance.

### **Lesson 2 - Properties of Different Surface Finishes**

**At the end of Lesson 2, you should be able to:**

- 2.1 List the strengths and weaknesses of various surface finishes.
- 2.2 Decide which finish is appropriate for a particular function.

## **SECTION B – General Principles of Electroplating**

### **Lesson 3 - Why Electroplating is used as a Coating Method**

**At the end of lesson 3, you should be able to:**

- 3.1 Explain why electroplating is such a popular way of putting metal coatings onto substrates.
- 3.2 Deduce what properties of a plated coating should be specified so that the plated part should be suitable for a certain use.
- 3.3 List the main processes in a typical plating sequence.
- 3.4 State why it is so important to rinse the parts in water after different processes

## **Lesson 4 - Basic Electroplating Circuits and Calculations**

**At the end of lesson 4 you should be able to:**

- 4.1 List the main components of an electroplating electrical circuit and draw the associated circuit diagram.
- 4.2 Know the parameters and their units for the control of the electrical supply to an electroplating tank.
- 4.3 Calculate the operating parameters associated with the electrical supply to an electroplating tank.

## **SECTION C - Chemical Reactions at the Surface of an Electrode**

### **Lesson 5 - Chemical Symbols and Chemical Equations**

**At the end of lesson 5 you should be able to:**

- 5.1 Write the chemical symbols for the chemicals used most often in electroplating
- 5.2 Write chemical equations for simple chemical reactions.
- 5.3 Understand how atoms join together by ionic, covalent and metallic bonds.

### **Lesson 6 - Electrode Reactions in Electroplating**

**At the end of Lesson 6, you should be able to:**

- 6.1 Explain the difference between a homogeneous and a heterogeneous reaction.
- 6.2 Identify an electrochemical reaction
- 6.3 List different types of cathode reduction reactions

### **Lesson 7 - Electrode Reactions and Faraday's Laws**

**At the end of Lesson 7 you should be able to:**

- 7.1 Identify different anodic reactions
- 7.2 List problems of secondary cathodic reactions
- 7.3 Understand the effect of imbalance of cathode and anode efficiencies
- 7.4 Recognise a Faradaic Reaction and know how its rate can be measured.

## **Lesson 8 - Electrode Reactions and Deposition Rate**

**At the end of Lesson 8 you should be able to:**

- 8.1 List the factors affecting the rate of a Faradaic Reaction.
- 8.2 Understand what makes a reaction take place and what causes the reactants to reach the surface.
- 8.3 Understand why there are limits to the maximum plating rate
- 8.4 Understand that substances adsorbed onto a cathode surface can affect electrodeposition

## **SECTION D - Care and Maintenance of Solutions and Product Quality**

### **Lesson 9 – The Physical and Chemical Properties of Electroplating Solutions**

**At the end of Lesson 9 you should be able to:**

- 9.1 List the components of an electrodeposition bath.
- 9.2 Explain the role played by each component.
- 9.3 Measure pH, metal ion concentration and solution density.

### **Lesson 10 - The Structure of Electrodeposits**

**At the end of Lesson 10 you should be able to:**

- 10.1 Recognise the major microstructural features of an electrodeposited metal.
- 10.2 Recognise the major macrostructural features of an electrodeposited metal.
- 10.3 Recognise the factors giving good adhesion of electrodeposited metals.
- 10.4 Recognise that metals may be deposited in a state of tensile or compressive stress.
- 10.5 Appreciate that metals can be co-deposited with other metals to form alloys and that non-metallic particles can be co-deposited with metals to form composite coatings.

### **Lesson 11 – Testing Electroplated Coatings**

**At the end of Lesson 11 you should be able to:**

- 11.1 List deposit properties to control.
- 11.2 Describe techniques for measuring the thickness deposits.
- 11.3 Describe test methods for deposit properties.

## **Lesson 12 – Process Control and the Hull Cell**

**At the end of Lesson 12 you should be able to:**

- 12.1 Explain the meaning of Process Control.
- 12.2 Explain the benefits of Process Control.
- 12.3 Keep a log of a Surface Finishing Process.
- 12.4 Use a Hull cell.
- 12.5 Explain the importance of Plant Control.
- 12.6 Appreciate what a Hull cell test can show.
- 12.7 Appreciate some Hull cell test applications.
- 12.8 List common faults that can occur when electroplating.
- 12.9 Identify sources of contamination which affect product quality.
- 12.10 Know how to remove contamination from plating solutions.

## **SECTION E – Introduction to Corrosion**

### **Lesson 13 - How Coatings can prevent Corrosion**

**At the end of lesson 13 you should be able to:**

- 13.1 Define corrosion and understand its consequences.
- 13.2 Understand the chemistry of corrosion of iron.
- 13.3 Understand the electrochemical nature of the aqueous corrosion of metals.
- 13.4 Know how the electrochemical series can be used to select coatings for the prevention of corrosion.
- 13.5 Understand the importance of the electrochemical series.
- 13.6 Understand how coatings prevent corrosion.
- 13.7 Describe the need for accelerated corrosion tests for coated products and explain the main tests.

## **SECTION F - Anodising**

### **Lesson 14 - The Principles of Anodising**

**At the end of lesson 14, you should be able to:**

- 14.1 Understand what is meant by the term ‘anodising’.
- 14.2 Describe what metals are practically anodised.
- 14.3 Describe the structure of anodically formed oxide on aluminium.
- 14.4 List the various conditions which can be used to anodise aluminium and how these affect the properties and thickness of the oxide thus formed.
- 14.5 Describe the differences between anodising and electroplating.
- 14.6 List the advantages and disadvantages of anodising.
- 14.7 List applications of anodised aluminium.
- 14.8 Know the advantages of plasma electrolytic oxidation.

## **Lesson 15 - The Anodising of Aluminium**

**At the end of lesson 15, you should be able to:**

- 15.1 Describe how to jig components for anodising.
- 15.2 Describe how to anodise a sample of aluminium in a sulphuric acid electrolyte.
- 15.3 Describe how to colour a sample of anodised aluminium and seal it.
- 15.4 Describe the chromic acid anodising process
- 15.5 Compare the oxide films produced by sulphuric and chromic acid anodising.
- 15.6 Know about other electrolytes for anodising aluminium.

## **SECTION G - Services**

### **Lesson 16 - Water chemistry, utilities and prime services**

**At the end of lesson 16 you should be able to:**

- 16.1 Appreciate the meaning and purpose of utilities and prime services in the Finishing Shop.
- 16.2 Realise the importance of water and know what it is.
- 16.3 Be aware of the properties of water.
- 16.4 Know about the treatment of water.
- 16.5 Be aware of the quality of deionised water.
- 16.6 Appreciate the value of water as a heat transfer fluid for cooling and heating.
- 16.7 Understand the key properties of utilities and services.
- 16.8 Be knowledgeable of the Factory Coding System.

## **SECTION H – HEALTH, SAFETY AND ENVIRONMENTAL ISSUES IN SURFACE FINISHING**

### **Lesson 17 – Health, Safety and Environmental Legislation**

**At the end of Lesson 17 you should be able to:**

- 17.1 Understand what is required of an employer under the Health & Safety at Work Act (1974).
- 17.2 Understand what is required of an employee under the Health & Safety at Work Act (1974).
- 17.3 Be aware of the requirements of Control of Substances Hazardous to Health Regulations (COSHH).
- 17.4 Understand the need for and the principles of risk assessments and their relevance to COSHH and the Health and Safety at Work Act.
- 17.5 Be aware of the use of Pictograms and Hazard and Precautionary phrases for identifying the hazards of Hazardous Substances.
- 17.6 Be aware of REACH.
- 17.7 Understand the role of the main environmental legislation concerning permits, waste and pollution of water.
- 17.8 Be aware of other legislation that may affect the processes used in surface finishing.

## Lesson 18 – Health and Safety Hazards and Precautions

**At the end of Lesson 18 you should be able to:**

- 18.1 List and identify the most important items of safety equipment in a surface finishing department.
- 18.2 Identify the most common hazards to be found in the workplace.
- 18.3 Be aware of the most common chemical hazards.
- 18.4 Identify the principal hazards in the electroplating shop.
- 18.5 Be aware of specialist hazards to be found in other types of surface finishing areas.
- 18.6 Know how to avoid any short- and long-term effects of these hazards.
- 18.7 Discuss the importance and role of training in the prevention of accidents.
- 18.8 Know how to avoid a fire and to mitigate its effects.

## Lesson 19 – The Treatment and Disposal of Metal Finishing Wastes

**At the end of Lesson 19 you should be able to:**

- 19.1 Discuss how the discharge of hazardous effluents can cause danger, damage or loss.
- 19.2 List the main hazardous wastes from Surface Finishing.
- 19.3 Explain how heavy metal ions can be removed by alkaline precipitation and flocculation.
- 19.4 List the main methods for disposal of cyanides.
- 19.5 Discuss how to minimise the amounts of waste produced.
- 19.6 Explain the principles of ion-exchange and its application to effluent treatment.
- 19.7 Discuss the concept that valuable materials can be recovered from effluent streams.
- 19.8 List alternatives to precipitation for recovery or removal of metal ions from effluent streams.
- 19.9 Discuss methods for reducing water usage.
- 19.10 Identify how energy is wasted.