Advisory Circular

AC66-2.1B

Revision 2 (3)

Aircraft Maintenance Engineer Licence – Examination Subject 1B Aeronautical Science – Electrical Fundamentals

14 December 2021

General

Civil Aviation authority advisory circulars contain information about standards, practices, and procedures that the Director has found to be an **acceptable means of compliance** with the associated rule.

An acceptable means of compliance is not intended to be the only means of compliance with a rule, and consideration will be given to other methods of compliance that may be presented to the Director. When new standards, practices, or procedures are found to be acceptable they will be added to the appropriate advisory circular.

An advisory circular may also include **guidance material** to facilitate compliance with the rule requirements. Guidance material must not be regarded as an acceptable means of compliance.

This advisory is intended to be read in conjunction with Part 66 Subpart B of the rule. If there are any conflicts between the advisory circular and the rule, the rule takes precedence.

Purpose

This advisory circular provides an acceptable means of compliance for the syllabus content in respect of written examinations for Subject 1B (Aeronautical Science - Electrical Fundamentals).

Related Rules

This advisory circular relates specifically to Civil Aviation Rule Part 66 Subpart B - Aircraft Maintenance Engineer Licence.

Change Notice

Subject to “Memorandum for Technical Cooperation” between the CAA of Mongolia and New Zealand on mutual cooperation in implementation of the International Civil Aviation Organization Resolution of Global Rule Harmonization, which urges States to promote global harmonization of national rules, dated 6th of May, 1999, Mongolian Civil Aviation Safety Regulation has been reconciled to the Civil Aviation Regulation of New Zealand.

Amendment 164 of Annex 1 to the Chicago Convention on International Civil Aviation urges flight crew members, ATC personnel and aircraft maintenance engineers to comply with the language proficiency requirements; and

Under Article 14 of the Civil Aviation Law of Mongolia 1999, “Use of foreign language in civil aviation” the AC has been released in English version only, in order to prevent any mistranslation and misuse of the aviation safety related documents.

In Revision 2, editorial changes were made to standardize formatting and to correct references specific to New Zealand.

Table of Contents

Rule 66.53 Eligibility Requirements

Rule 66.53(a)(2) requires an applicant for an AMEL to have passed written examinations that are acceptable to the Director, relevant to the duties and responsibilities of an aircraft maintenance engineer in the category of licence sought.

The written examinations acceptable to the Director for Subject 1B (Aeronautical Science - Electrical Fundamentals) should comply with the syllabus contained in this advisory circular. Each examination will cover all topics and may sample any of the sub-topics.

The new syllabus has been developed after extensive industry consultation and the objectives reflect the knowledge required of current technology and international best work practice.

Examination Overview: Subject 1B

Subject 1B (Aeronautical Science - Electrical Fundamentals) is a closed book, written examination. The pass mark for subject 1B is 70%.

Application to sit an examination may be made directly to PEL office.

General Examining Objective

The objective of the examination is to determine that the applicant for an AMEL has adequate knowledge of Electrical Fundamentals to permit the proper performance, supervision and certification of aircraft maintenance at a level commensurate with the privileges of the various AMEL categories.

Knowledge Levels

Level 1: A familiarisation with the principal elements of the subject

Objectives: The applicant should be:

1) familiar with the basic elements of the subject
2) able to give simple descriptions of the whole subject, using common words and examples
3) able to use typical terms.

Level 2: A general knowledge of the theoretical and practical aspects of the subject

An ability to apply the knowledge.

Objectives: The applicant must be able to:

1) understand the theoretical fundamentals of the subject
2) give a general description of the subject using, as appropriate, typical examples
3) use mathematical formulae in conjunction with physical laws describing the subject
4) read and understand sketches, drawings and schematics describing the subject
5) apply his/her knowledge in a practical manner using detailed procedures

Level 3: A detailed knowledge of the theoretical and practical aspects of the subject.

A capacity to combine and apply the separate elements of knowledge in a logical and comprehensive manner.

Objectives: The applicant must:

1) know the theory of the subject and the interrelationships with other subjects
2) be able to give a detailed description of the subject using theoretical fundamentals and specific examples
3) understand and be able to use mathematical formulae related to the subject
4) be able to read, understand and prepare sketches, simple drawings and schematics describing the subject
5) be able to apply his/her knowledge in a practical manner using manufacturer's instructions

6) be able to interpret results and measurements from various sources and apply corrective action where appropriate.

Recommended Study Material

The publication list below provides guidance material for suitable study references for the overall syllabus content. However, applicants may have to conduct further research using other references or sources (including the internet) or attend a formal course in order to gain a comprehensive understanding of all sub-topics in the syllabus.

Where applicable, publication references have been placed below each main topic or sub topic heading in this syllabus.

Publication List

Study Ref	Book Title	Author	ISBN
1	A & P Technician General Textbook	Jeppesen	0-88487-203-3
2	Aviation Maintenance Technician Series - General	Dale Crane	1-56027-422-0
3	A & P Technician Airframe Textbook	Jeppesen	0-88487-205-1
4	Aircraft Batteries - Lead Acid/Nickel Cadmium	Jeppesen	0-89100-410-6
5	Aircraft Electrical Systems	E.H.J. Pallett	0-582-98819-5
6	Electrical Systems for A&Ps	Jeppesen	0-89100-412-2
7	Dictionary of Aeronautical Terms	Dale Crane	1-56027-287-2

Syllabus Layout

Topic Numbering - left hand column

The syllabus is set out by topics, each of which is identified by a single-digit number. Each topic is divided into a number of sub-topics, which are identified by two-digit numbers: the first and second digits of which refer to the topic and the sub-topic respectively.

Each sub-topic is further sub-divided into one or more sub-sub-topics, which are identified by three-digit numbers. Where applicable, sub-sub-topics may be further subdivided into paragraphs that are identified by four/five digit alphanumeric sequences.

The three-digit sub-sub-topic numbers shown in the left hand column are used in the ‘knowledge deficiency reports’ to provide feedback on individual examinations.

Objective description - middle column

The middle column objectively describes each sub-sub-topic by stating, in plain language, its subject matter and the type of performance or activity required. The objectives are intended to be simple, unambiguous, and clearly-focussed, outcomes to aid learning.

Knowledge levels - right hand column

The right hand column specifies the knowledge level for each sub-topic heading. The three levels of knowledge used in this syllabus are described above. Note that the knowledge levels indicate the depth of knowledge required NOT its safety importance.

Syllabus: Subject 1B (Aero. Science - Electrical Fundamentals)

1	Electrical Theory	
	Study Ref. 1 2 7	
1.1	**Electron Theory**	
1.1.1	Outline the structure and distribution of electrical charge within: a. Atoms b. Compounds c. Ions d. Molecules	1
1.1.2	Describe the molecular structure of the following with examples: a. Conductors b. Semi-conductors c. Insulators	2

2	Generation of Electricity	
	Study Ref. 1 2	
2.1	**Sources of Electricity**	
2.1.1	Specify how electricity is produced by the following, with examples: a. Chemical action b. Friction c. Heat d. Light e. Magnetism and motion f. Pressure	1
2.2	**Laws of Electricity Production**	
2.2.1	Describe Fleming's left and right hand rules and their application.	1
2.2.2	State: a. The laws of electrostatic attraction and repulsion. b. The units of charge and describe Coulomb's law. c. Faraday's law	2

2.3	**Electrical Terminology**	
2.3.1	Define the following terms: a. Charge b. Conductance c. Current flow d. Electromotive force e. Potential difference f. Resistance g. Voltage	1
2.3.2	List the units and symbols for each of the electrical terms listed in 2.3.1.	1
2.3.3	Outline factors affecting the performance of each of the terms listed in 2.3.1, including their impact on circuit performance.	1

3	**Static Electricity**	
	Study Ref. 1 2	
3.1	**Static Electricity and Conduction**	
3.1.1	Describe how static electricity is produced and how electrostatic charges are distributed.	2
3.1.2	Describe: a. The concept of electric current as a flow of free electrons. b. The conduction of electricity in solids, liquids and gasses.	2
3.1.3	Differentiate between positive and negative charges	1
3.1.4	Explain the attraction and repulsion of positive and negative charges.	1
3.1.5	State the direction of an electrical field around positive and negative charges.	1
3.1.6	Describe: a. The distribution of charges on a regular shaped solid, hollow disc or sphere. b. The electrical charge distribution on an irregular shaped object.	1
3.1.7	Specify how electrostatic charges are distributed throughout aircraft structure and components.	2
3.1.8	Describe: a. Electrostatic fields as they occur in aircraft b. Electrostatic lines of force as they leave a charged body.	2
3.1.9	Compare the effects of attraction and repulsion on parallel current carrying conductors.	1

4	Chemical Action	
	Study Ref. 1 2 4 5 6 & 7	
4.1	**Cells**	
4.1.1	Outline the construction and basic chemical action of the following sources of electricity: a. Primary cells b. Secondary cells c. Lead acid cells d. Nickel-cadmium cells e. Other alkaline cells	1
4.1.2	Specify the effects of connecting cells in series and parallel.	1
4.1.3	Compare the difference between primary or dry cells and secondary cells.	1
4.1.4	Name the types of primary cells that may be found in aeronautical applications.	1

5	Other Sources of Electricity	
	Study Ref. 1 2 4 5 6 & 7	
5.1	**Heat**	
5.1.1	Specify the construction, materials and operation of a thermocouple.	1
5.2	**Light**	
5.2.1	Outline the operation of a photocell.	1

6	Batteries	
	Study Ref. 1 2 4 5 6 & 7	
6.1	**Terminology**	
6.1.1	State common terms used in the maintenance, operation and storage of aircraft batteries	1
6.2	**Lead Acid Batteries Construction**	
6.2.1	Describe the construction of a common lead acid aircraft battery.	2
6.2.2	Describe the two types of lead-acid battery found in general use with particular reference to the electrolyte characteristics.	2
6.2.3	Using appropriate terminology, describe the chemical action of a lead acid battery during charging and discharging.	2
6.2.4	Specify the effect that the battery's internal resistance has on its operations.	2
6.2.5	Describe the energy transformation (mechanical/electrical/chemical) that takes in an aircraft battery during the charging and discharge processes.	2

6.2.6	Identify the changes that take place to the electrolyte.	2
6.2.7	Define specific gravity or relative density relating to battery electrolytes.	2
6.3	**Lead Acid Battery Charging**	
6.3.1	State the open circuit voltage limits of a fully charged cell.	2
6.3.2	Identify the causes of changes to plate resistance.	2
6.3.3	Describe and calculate battery capacity ratings.	2
6.3.4	List the factors that affect ratings.	2
6.3.5	Describe the discharge characteristics at the five-hour rate.	2
6.3.6	With respect to charging a lead acid battery, identify: a. The cause of gassing b. The type of gas produced c. When in the charging cycle gassing is most intense.	2
6.3.7	Identify the cause of sulphation.	2
6.3.8	Describe the effect sulphation has on the life and operation of batteries.	2
6.3.9	Describe the SG of a battery at various states of charge and how temperature affects the SG reading.	2
6.3.10	From given data, calculate battery efficiency after the charging process has been completed.	2
6.4	**Lead Acid Battery Maintenance and Storage**	
6.4.1	Describe the following: a. The safety precautions associated with mixing of electrolyte b. How to neutralise spills c. How to vary a battery's SG d. Segregation requirements for acid and alkaline electrolytes e. Protective clothing required when handling batteries and solutions f. Fire precautions and protection g. Correct electrolyte levels h. Stand down times after charging i. How to identify a fully charged battery during the charging operation j. Desirable load conditions applied to a battery when checking maximum EMF and capacity k. Environmental hazards associated with lead acid batteries	2
6.4.2	Specify the precautions to be observed when: a. Carrying out maintenance on and around installed aircraft batteries and	2

	battery installations. b. Fitting or removing an aircraft battery, including the removal and replacement sequence of battery leads. c. Charging multiple batteries off the same power source	
6.4.3	Detail the following procedures: a. Preparing a new or stored battery (dry or uncharged) for service, including initial filling b. Preparing to charge a battery	2
6.4.4	Explain the use of a battery hydrometer in the testing of batteries.	1
6.4.5	Describe the principles of operation of the hydrometer, including the float levels and graduations relating to a battery at various states of charge.	2
6.4.6	State the constant voltage and current methods of recharging batteries.	2
6.4.7	Outline: a. How deposits are formed on battery terminals b. The adverse effects of the deposits c. How terminal posts should be cleaned and protected.	2
6.4.8	Identify the causes and remedies of the following battery defects: a. Loss of capacity b. Constant requirement to add water c. Rapid accumulation of deposits on terminals d. Plate buckling e. Case damage f. Melting of insulation g. Excessive venting or gassing	2
6.4.9	Describe the storage requirements for lead acid batteries.	1
6.5	**Nickel-Cadmium Batteries Overview**	
6.5.1	Compare the main advantages and disadvantages of nickel-cadmium batteries over lead acid batteries for aircraft use.	1
6.5.2	Compare internal resistances between a nickel-cadmium and lead-acid battery types.	1
6.6	**Nickel-Cadmium Batteries Construction**	
6.6.1	Describe the following designs of nickel-cadmium battery: a. Sealed batteries b. Semi-sealed batteries c. Semi-open batteries	1

6.6.2	State the chemical principles relating to charging and discharging a nickel-cadmium battery with particular emphasis on the following: a. Exchange of ions b. Plate oxidation c. Composition of plates and basic plate materials d. Chemical composition and SG of electrolyte e. SG changes during charge and discharge f. Cause of gassing, the effect gassing has on electrolyte levels and the requirement to add water g. Electrolyte temperature h. Change of electrolyte state during charge and discharge i. Charging voltage j. Individual cell voltage k. Internal resistance	1
6.6.3	Graph the discharge characteristics of a nickel-cadmium battery with respect to discharge current versus time.	1
6.6.4	Describe battery construction of a nickel-cadmium battery.	2
6.6.5	State the number of cells normally found in 12 and 24-volt nickel-cadmium aircraft batteries.	1
6.7	**Nickel-Cadmium Batteries Charging**	
6.7.1	Identify the following battery charging equipment: a. Constant voltage and constant current chargers b. Ni-cad charger/analyser c. Load banks d. Voltage monitors	1
6.7.2	Specify the following storage criteria for nickel-cadmium batteries: a. Charge state b. Double charge and capacity check	1
6.8	**Nickel-Cadmium Batteries Maintenance and Storage**	
6.8.1	Specify the procedure and safety precautions for servicing nickel-cadmium batteries.	2
6.8.2	Specify with the purpose and operating principles of the following installed equipment associated with the in-service operation of nickel-cadmium batteries: a. Temperature sensing equipment b. Current sensing equipment	1

	c. Voltage sensing equipment	
6.8.3	Describe thermal runaway with particular regard to: a. The causes of high temperatures during charge and discharge b. Indications of thermal runaway c. The adverse effects of high temperatures on internal resistance d. The thermal runaway cycle (vicious cycling) e. How thermal runaway is monitored - location and use of temperature sensors f. Modern methods of controlling thermal runaway	2
6.8.4	Identify with the probable cause and corrective action of the following nickel-cadmium battery defects: a. High continuous trickle charge b. Battery fails to pass ampere-hour check c. Battery fails to deliver rated capacity d. No potential available e. Excessive white crystal deposits f. Excessive water consumption g. Heat or blue marks on hardware h. Excessive corrosion of hardware i. Distortion of cell case	1
6.8.5	Specify the following storage criteria for nickel-cadmium batteries: a. Storage periodicity and limitations b. Terminal protection c. Inspection intervals d. Storage environment	1

7	Magnetism	
	Study Ref. 1 2	
7.1	**Properties of a Magnet**	
7.1.1	Describe the properties of a magnet and the molecular theory of magnetism, including: a. Artificially made magnets b. Domain theory c. Laws of attraction and repulsion d. Magnetic shielding techniques and shielding materials e. Magnetisation and demagnetisation f. The action of a magnet suspended in the earth's magnetic field	2
7.1.2	Identify the various types of magnetic material.	2
7.1.3	Specify the precautions associated with the handling, care and storage of permanent magnets, including the requirement for keepers.	2
7.2	**Electromagnetism**	
7.2.1	Specify how the following factors affect the magnitude of an induced current in a conductor as it passes through a magnetic field: a. Magnetic field strength b. Angle at which the magnetic lines are cut c. Rate at which the magnetic field is cut	1
7.2.2	Define the following terms and their relationship in a magnetic circuit: a. Coercive force b. Flux density c. Permeability d. Reluctance e. Retentivity f. Saturation	2
7.2.3	Describe the construction and principles of operation of electromagnets.	2
7.2.4	Specify the use of the handclasp rules to determine the direction of the magnetic field about a current carrying conductor (electron and conventional flow).	2
7.2.5	With respect to electromagnets: a. Define magneto motive force (MMF) and field intensity b. Identify electromagnetic units c. Calculate MMF and field intensity from given data.	2

7.2.6	In relation to electromagnets, describe: a. The action and field patterns where two current carrying conductors are placed adjacent to each other. b. The handclasp rules to determine the direction of north and south poles and the direction of current flow through a coil.	2
7.2.7	List the factors that affect the strength of a magnetic field in an electromagnet.	2
7.2.8	Describe the B-H curve and the significance of a hysteresis loop.	2
7.2.9	With respect to eddy currents, describe: a. How they are produced b. Their effects on the performance of an electromagnetic component c. The methods used to reduce adverse effects.	2
7.2.10	Specify the precautions for the care and storage of electromagnets.	2
7.3	**Induction**	
7.3.1	Describe how voltage is induced within a conductor.	2
7.3.2	Specify the effect of the following criteria on the magnitude of an induced voltage: a. Magnetic field strength b. The number of conductor turns c. The rate of change of flux	2
7.3.3	Describe the production of an induced voltage in a secondary coil (mutual inductance).	2
7.3.4	Specify the effects that the rate of change of primary current and mutual inductance have on the value of an induced voltage.	2
7.3.5	Describe how the following factors affect mutual inductance: a. Permeability of each coil b. Position of the coils with respect to each other c. The number of turns in each coil d. The physical size of each coil	2
7.3.6	Describe: a. Back EMF b. Lenz's Law and the rule for determining the polarity of an induced voltage c. The production of an induced voltage in a coil. (self-induction) d. The unit of inductance	2
7.3.7	Explain the condition known as saturation.	2
7.3.8	Describe the following types of fixed inductors:	2

	a. Air core b. Ferrite core c. Iron dust core d. Laminated core	
7.3.9	Specify the following methods of varying the value of an inductor: a. Adjustable slug b. Slider contact on a coil c. Tapped coil d. Variometer	2
7.3.10	Identify the following common faults in inductors: a. Open coil b. Shorted turns	2
7.3.11	Illustrate the principal uses of inductors.	2
7.3.12	State the purpose of an iron core in an electromagnetic device.	2

8	Alternating Current (AC)	
	Study Ref. 1 2 5 & 6	
8.1	**Sinusoidal Wave Form Analysis**	
8.1.1	Outline the general principles of AC generation in respect of: a. Single phase b. Three phase	2
8.1.2	In relation to voltage, current and power, define the following: a. Average b. Instantaneous c. Peak d. Peak to peak e. Root mean square (RMS)	1
8.1.3	Perform calculations involving voltage, current and power, given variables.	2
8.1.4	Describe sinusoidal waveform with respect to the following: a. Angular velocity (Radians) b. Cycle c. Frequency and resonant frequency d. Period e. Phase	2
8.1.5	With respect to sinusoidal waveform, perform calculations given variables.	2
8.1.6	Identify the functions and effects of the following waves: a. Triangular b. Square.	2
8.1.7	Calculate the effects on frequency with variation in the number of alternator poles and RPM.	2
8.1.8	Describe harmonics and the effect that odd and even harmonics have on fundamental wave shapes.	2

9	Direct Current (DC)	
	Study Ref. 1 2 5 & 6	
9.1	**Theory of Operation**	
9.1.1	Describe how AC to DC current rectification is achieved in a basic aircraft system.	2
9.1.2	Describe the following factors pertaining to the operation of a DC generator: a. The left-hand rule b. Production of a current in a conductor c. Graphical representation through 360 degrees, the output of an elementary generator d. Graphical representation of the effects of commutation on the output of a generator through 360 degrees e. The effects of multiple armature loops on generator output f. Multiple poles g. Ripple output and how it is reduced h. Excitation and self-excitation i. Residual magnetism	2
9.2	**Types of DC Generator**	
9.2.1	Describe the construction, principles of operation and general characteristics of the following types of DC generator: a. Self-excited b. Series-wound c. Shunt-wound d. Compound-wound e. Differential-compounding f. Cumulative-compounding g. Starter generators	2
9.2.2	Describe the advantages, disadvantages and aeronautical applications of various types of DC generators.	2
9.2.3	State which type of generator is most commonly found in light aircraft applications.	2
9.2.4	Compare the voltage/load characteristics of the various types of DC generators.	2
9.2.5	Describe: a. How aircraft DC generators are typically rated b. The importance of rating	2

	c. Where the rating may be found	
9.2.6	Define the term “coming in speed” with respect to a generator coming on line.	2
9.2.7	Specify the importance of direction of rotation and how it is determined.	2
9.3	**DC Generator Construction**	
9.3.1	Outline the construction of a typical 24-volt aircraft DC generator including the function and operation of the following components: a. Armature b. Commutator; segments, risers, mica separators and wedges c. Slots d. Coils e. Shaft f. Splined drive g. Field frame h. Field windings i. Bearing arrangement j. Brushes, springs and holders k. Pole shoes l. Laminated cores m. Air scoop n. Terminal posts or boxes	2
9.3.2	Specify the significance of A, F and E terminals and what electrical connections would normally be made at each.	2
9.4	**Maintenance**	
9.4.1	Identify the cause and effects of armature reaction in a DC generator.	2
9.4.2	Specify how armature reaction is corrected through the use of inter-poles or brush placement.	2
9.4.3	Describe the following activities associated with the in-service maintenance of generators: a. Installation procedures b. Checking and adjustment of drive belts c. Commutator serviceability d. Brush, brush holder, and spring serviceability e. Spring tension checks f. Cleaning of parts	2

	g. Insulation checks h. Checks for field shorts i. Checks for armature shorts j. Bedding of brushes k. Rectification of typical generator defects l. Voltage regulator operation m. Load considerations when making voltage adjustments	
9.4.4	Outline the basic principles of how the output voltage is normally regulated on a DC generator.	2
9.4.5	Describe the testing of a DC generator with particular regard to the following: a. Low or no output b. Type of equipment used c. Identification and likely causes of defects	2

10	**Aircraft Alternators**	
	Study Ref. 1 2 5 & 6	
10.1	**Types of Aircraft Alternator**	
10.1.1	Describe the following types of alternator in aeronautical use: a. DC alternators b. AC alternators - Constant frequency and frequency wild systems c. Inverters (static and rotary)	2
10.1.2	State the advantages, disadvantages, and common applications of each type of alternator:	2
10.2	**Construction**	
10.2.1	Describe the construction of a DC alternator with particular regard to the following: a. Rotor shaft b. Rotor windings c. Segments and fingers d. Slip rings e. Brushes f. Stator frame (laminated soft iron) g. Stator windings or coil sets h. Coil connections	2

	i. Rectifier diodes	
10.3	**Operation**	
10.3.1	Specify the principles of operation of a DC alternator with particular regard to the following: a. Three phase stator configuration b. Output current c. "Y" connections d. Wave form during 360 degree rotation e. AC rectification and voltage reduction for battery charging f. Voltage control g. Transistorised voltage regulators	2
10.3.2	Define what is meant by the term rectification.	1
10.3.3	State how rectification is achieved in an AC system.	2
10.4	**Maintenance**	
10.4.1	Identify the following faults relating to an alternator not producing power, and how they would be found and rectified: a. Open field circuit b. Shorted or open diode in the rectifier circuit	2
10.4.2	Specify the effects of battery polarity on rectifying diode serviceability.	2
10.4.3	Describe the adverse effects of flashing the field on a DC alternator.	2
10.4.4	Describe the importance of electrical load during DC alternator operation.	2

11	**DC Motors**	
	Study Ref. 1 2 5 & 6	
11.1	**Types of DC Motor**	
11.1.1	Describe the following types of DC motors: a. Series wound b. Shunt wound c. Compound wound	1
11.1.2	Compare the advantages and disadvantages of types of motors.	2
11.1.3	Specify typical aeronautical applications for each type of motor.	2
11.1.4	Graph the speed/load characteristics of the various types of DC motor	2
11.1.5	State how speed may be controlled in a no-load situation.	
11.1.6	Explain how electrodynamic braking is achieved in an electric motor, including control of field and armature currents.	2
11.2	**Construction**	
11.2.1	Describe the construction, armature and field connections of the following types of DC motor: a. Series wound b. Shunt wound c. Compound wound	2
11.3	**Operation**	
11.3.1	Describe the principles of operation of the following types of DC motor: a. Series wound b. Shunt wound c. Compound wound	2
11.3.2	Describe the following: a. Right hand rule for basic motor operation b. The effects of parallel current carrying conductors c. Developing torque d. Principles of operation of the basic DC motor e. The purpose of having two field windings wound in opposite directions	2
11.3.3	Specify how the following functions are achieved: a. Motor speed change b. Reversing motor direction	2

	c. Motor braking (mechanical and electrodynamic)	
11.4	**Electrically Powered Actuators**	
11.4.1	With regard to actuators in an aircraft electrical system, describe the following: a. Typical applications for linear and rotary types b. Types of electrical motor used c. Braking systems commonly used d. Speed control e. Reversing devices f. Travel adjustment g. Maintenance requirements	2
11.5	**Maintenance**	
11.5.1	Identify the following losses that occur when electrical energy is converted into mechanical energy. a. Copper losses b. Iron losses c. Eddy current losses	1
11.5.2	Explain how losses caused during energy conversion may be minimised.	1
11.5.3	Identify the cause and effects of back EMF in a motor armature relative to the various types of motor.	1
11.5.4	Describe the following inspection and maintenance activities associated with DC motors: a. Brush serviceability checks b. Commutator serviceability c. Wiring and connections d. Bearings e. Lubrication requirements f. Requirements for a load when testing a series wound motor removed from the aircraft system	2

12	Transformers	
	Study Ref. 1 2 & 5	
12.1	**Transformer Principles**	
12.1.1	Describe construction and operating principles of a transformer.	1
12.1.2	Identify transformer losses and state how they are minimised.	1
12.1.3	Specify the action of a transformer under the following conditions: a. Load b. No load c. Resistive load d. Inductive load e. Capacitive load	1
12.1.4	Describe power transfer, efficiency and the relevance of polarity markings.	1
12.1.5	From given data calculate: a. Efficiency b. Power c. Primary or secondary current d. Primary or secondary voltage e. Turns ratio	2
12.1.6	Specify the operation and use of autotransformers, current transformers and variacs.	1

13	Resistance	
	Study Ref. 1 2	
13.1	**Resistance**	
13.1.1	Describe resistance and factors that affect its value.	1
13.1.2	Define the following terms. a. Positive and negative temperature coefficient b. Conductance c. Specific resistance	1
13.2	**Resistors**	
13.2.1	Specify the composition, performance (stability and tolerance) and limitations of the following fixed resistors: a. Carbon composition b. Carbon film c. Metallic film d. Wire wound	1
13.2.2	Outline the following types of variable resistor: a. Carbon film b. Thermistor c. Voltage dependent resistor and varistor d. Wire wound	1
13.2.3	Identify resistor colour codes, values and tolerances.	2
13.2.4	Describe the system of preferred values and wattage ratings.	2
13.2.5	State the factors that affect the resistance of a wire conductor.	3
13.2.6	Outline the construction and use of potentiometers and rheostats.	1
13.2.7	State the effect on the output voltage when the load is varied.	1
13.2.8	Describe the characteristics of a good insulator material.	2
13.3	**Power**	
13.3.1	Specify the dissipation of power by a resistor.	2
13.3.2	In electrical terms, define power, work, and potential and kinetic energy.	2
13.3.3	Convert horsepower to watts and vice versa.	2
13.3.4	State the power formula.	2
13.3.5	Describe the maximum power transfer theorem.	2
13.3.6	Perform calculations involving power, work and energy.	2

14	Capacitance	
	Study Ref. 1 & 2	
14.1	**Capacitance**	
14.1.1	State the unit of capacitance and explain the following relationships: a. C= KA/D b. Q=CV	2
14.1.2	Describe the following factors affecting capacitance: a. Area of the plates b. Dielectric and dielectric strength c. Dielectric constant d. Distance between the plates e. Number of plates	2
14.1.3	Describe the following factors: a. Relationship between capacitance and working voltage b. Voltage rating c. Working voltage d. Losses and efficiency	2
14.2	**Capacitors**	
14.2.1	Outline the basic construction and principle of operation of a capacitor.	2
14.2.2	Describe the construction, principles of operation and application of the following capacitors: a. Ceramic b. Electrolytic c. Mica d. Paper e. Tantalum	2
14.2.3	State the common types of variable capacitor.	2
14.2.4	State the preferred values of capacitors and the method of colour coding.	2
14.2.5	Explain the procedure for testing a capacitor with an ohmmeter and be able to identify the following: a. Leaking capacitor b. Open circuit c. Short circuit	2
14.2.6	Describe the exponential charge and discharge of a capacitor and state the time constant (T=CR).	2

14.2.7	Identify the main uses of a capacitor such as in: a. DC blocking b. Energy storage	2

15 Circuits		
	Study Ref. 1 & 2	
15.1	**Circuit Terminology**	
15.1.1	Define the following terms: a. Closed circuit b. Open circuit c. Short circuit	2
15.1.2	Define Ohm's law and Kirchhoff's voltage and current laws.	2
15.1.3	Perform calculations using the Ohm's and Kirchhoff's laws to find: a. Resistance b. Voltage c. Current in a circuit including the effects of adding or removing electrical components.	2
15.1.4	Describe the significance of the internal resistance of a supply.	2
15.1.5	Explain what causes the heating effect in a conductor.	3
15.2	**Series and Parallel Circuits**	
	Resistors	
15.2.1	Specify the effects of connecting resistors in series, parallel and combinations thereof.	2
15.2.2	Calculate total resistance using series, parallel and series-parallel combinations of resistors.	2
15.2.3	Perform resistance calculations from given information.	2
15.2.4	Describe the principles of a Wheatstone Bridge.	1
15.2.5	Perform calculations using potential dividers and a Wheatstone Bridge.	2
15.2.6	Describe the polarities of potential differences in resistive circuits and the potential at various points in a circuit.	1
	Capacitors	
15.2.7	Calculate capacitance and voltage for series and parallel circuits.	2

	Inductors	
15.2.8	Calculate total inductance in a series, parallel and series-parallel circuit.	2
15.2.9	Describe the exponential rise and fall of a current in an inductive resistive (LR) circuit.	2
15.2.10	Determine the time constant T=L/R.	2
15.3	**Series and Parallel Resonance**	
15.3.1	Define the following terms: a. Resonance b. Bandwidth	1
	Series Resonance	
15.3.2	Describe how the properties of a series reactive circuit change at resonance.	
15.3.3	When the frequency of a series resonant circuit is varied, describe the effect on: a. Current b. Impedance c. Phase angle	1
15.3.4	Describe and interpret frequency response curves for series resonant circuits.	2
15.3.5	From given information, calculate the resonant frequency of a circuit.	2
15.3.6	Describe and calculate the voltage magnification factor Q of a circuit.	2
15.3.7	Specify the effect that resonance has on Q and resonance curves.	1
15.3.8	Calculate bandwidth, given variables.	2
	Parallel Resonance	
15.3.9	Specify how the properties of a parallel resonant circuit change at resonance.	1
15.3.10	When the frequency of a parallel circuit is varied, describe the effect on: a. Current b. Impedance c. Phase angle	2
15.3.11	Describe and interpret frequency response curves for parallel resonant circuits.	2
15.3.12	Specify the operation and use of a tank circuit.	1
15.4	**Inductive, Capacitive and Resistive Circuits**	
15.4.1	In relation to series and parallel L, C and R circuits, describe the relationship between voltage and current across the circuit components.	2
15.4.2	Given a circuit diagram with variables, calculate: a. Applied and component voltage b. Current	2

	c. Impedance d. Phase angle e. Power factor	
15.4.3	Describe: a. True power b. Apparent power c. Reactive power	2
15.4.4	Given variables, calculate true, apparent and reactive power.	
15.4.5	Given variables in relation to purely resistive, capacitive and inductive circuits: a. Apply Ohm's Law to determine voltage, current and opposition to current flow. b. Calculate inductive and capacitive reactance and state the factors that affect them. c. Describe and calculate impedance and phase angle. d. Describe the power dissipation and phase relationship between voltage and current.	2
15.5	**Methods of Coupling**	
15.5.1	Describe the following factors in regard to coupling: a. Mutual inductive coupling b. Resistive coupling c. Auto-inductive coupling d. Capacitive coupling e. Equivalent resistance f. Coupling factor g. Resonance curves	1
15.6	**Voltage Regulation**	
15.6.1	Specify the following conditions and state the means of compensation required for each: a. Over-voltage b. Under-voltage c. Reverse current	2
15.6.2	Specify the operation of typical circuits designed to provide voltage protection.	1
15.6.3	Solve problems related to typical voltage regulation circuits.	2

15.6.4	Outline the basic principles of operation and typical uses of the following types of voltage regulator: a. Carbon pile b. Transistor and transistorised c. Vibrator d. Mechanical e. Cut-outs	2
15.6.5	With respect to a three-unit type regulator, describe the functions and operations of the following coils and how they interact with the system: a. Current limiter b. Reverse current c. Voltage regulator	2
15.6.6	Specify the purpose of generator paralleling with particular regard to following: a. Negative lead paralleling b. Positive lead paralleling	2

16	Electrical Drawings, Diagrams, Schematics & Symbols	
	Study Ref. 5 & 6	
16.1	**Symbols and Conventions - General**	
16.1.1	Reproduce the standard electrical system symbols and drawing conventions used to depict the following components in an aircraft electrical system: a. Polarity b. Direction of flow c. Test-point recognition symbols d. Adjustability or variability symbols e. Special property indicators for temperature dependence, magnetic field dependence and storage f. Physical-state recognition symbols for gas, air or pneumatic, liquid and solid g. Ground h. Electrical disconnect i. Lamp j. Alternating current source k. Permanent magnet l. Bus Bars m. Splice	1
16.2	**Conductors**	
16.2.1	Reproduce the following standard electrical system symbols for conductors: a. Single b. Electrical intersection c. Crossover d. Terminal	1
16.3	**Resistors**	
16.3.1	Reproduce the following standard electrical system symbols for resistors: a. General b. Tapped c. Adjustable contact d. Variable (Rheostat) e. Thermistor	1

	f. Photoconductive Transducer g. Piezoelectric crystal unit	
16.4 16.4.1	**Batteries** Reproduce the following standard electrical system symbols for batteries: a. One-cell b. Multi-cell	1
16.5 16.5.1	**Capacitors** Reproduce the following standard electrical system symbols for capacitors: a. General b. Electrolytic c. Fixed d. Variable e. Shielded f. Feed-through g. Polarised h. Variable with mechanical linkage	1
16.6 16.6.1	**Semiconductors** Reproduce the following standard electrical system symbols for semiconductors: a. Diode b. Zener diode c. Silicon controlled rectifier d. PNP transistor e. NPN transistor	1
16.7 16.7.1	**Transformers** Reproduce the following standard electrical system symbols for transformers: a. Basic b. Iron cored c. Auto	1
16.8 16.8.1	**Meters** Reproduce the following standard electrical system symbols for meters: a. Voltmeter b. Ammeter	1

16.9 16.9.1	**Generators** Reproduce the following standard electrical system symbols for generators: a. DC Generators (2 Symbols) b. AC Generator	1
16.10 16.10.1	**Motors** Reproduce the following standard electrical system symbols for motors: a. DC Motors (2 Symbols) b. DC Reversible c. AC Motors	1
16.11 16.11.1	**Fields, Generator or Motor** Reproduce the following standard electrical system symbols for fields in generators or motors: a. Compensating or commuting b. Series c. Shunt or separately excited	1
16.12 16.12.1	**Connectors** Reproduce the following standard electrical system symbols for connectors: a. Removable b. Fixed c. Bulkhead d. All pins shown e. Not all pins shown f. Pin and socket designations	1
16.13 16.13.1	**Circuit Breakers and Other Current Limiting Devices** Reproduce the following standard electrical system symbols for circuit breakers and other current limiting devices: a. Automatic reset b. Push reset c. Push reset pull off d. Switch type e. Momentary switch type	1

	f. IOA fuse g. Current limiter h. Circuit breaker with thermal overload device i. Circuit breaker with magnetic overload device	
16.14 16.14.1	**Thermocouples** Reproduce the following standard electrical system symbols for thermocouples: a. Temperature-measuring thermocouple with integral heater b. Thermocouple with integral insulated heater	1
16.15 16.15.1	**Solenoids and Relays** Reproduce the following standard electrical system symbols for solenoids and relays: a. Single pole single throw b. Single pole double throw c. Double pole single throw d. Double pole double throw e. Heavy duty contactor (Starter relay) f. Heavy duty contactor (AN Type) g. SPST Momentary on h. SPDT Normal or momentary contacts i. MPDT normal or momentary contacts	1
16.16 16.16.1	**Switches** Reproduce the following standard electrical system symbols for switches: a. Single pole single and double throw b. Double pole single and double throw c. Push switch normally open d. Push switch normally closed e. Temperature-actuated switch f. Flasher g. Contactor h. Limit switch i. Locking switch j. Knife switch	1

	k. Pressure or vacuum actuated switch l. Non locking switch m. Selector or multi position switch n. Multi-way transfer switch	
16.17 16.17.1	**Power Supply Connectors** Reproduce the following standard electrical system symbols for power supply connectors: a. Non-polarised male connector b. Non-polarised female connector c. Polarised female connector d. Polarised three-conductor connector, male e. Female contact f. Male contact g. Receptacle h. Plug i. Connectors engaged j. Coaxial connector	1
16.18 16.18.1	**Aircraft Electrical Drawings** Decode the following drawings pertaining to common general aviation type aircraft: (Examples Cessna and Piper) a. Electrical system schematic diagrams b. Block diagrams c. Assembly diagrams d. Trouble shooting flow charts e. Fault-tree analysis tables	1
16.19 16.19.1	**Title Blocks** Using the above drawing types, determine the following information: a. Title block format b. Line conventions c. Notes d. Abbreviations and component identification markings e. Drawing number f. Identification code	2

	g. Scale h. Equipment table i. Parts listings j. Revision details k. Wire codes and gauges l. Materials m. Terminals n. Assembly arrangements o. System/Component layout p. Component location q. Bulkhead and structural connections r. Special mounting and insulation requirements s. Identification of components with reference to aircraft wing and fuselage stations	
16.19.2	Extract information relevant to aircraft wiring installations from electrical wire charts.	2

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