CIVIL AVIATION AUTHORITY OF FIJI

GUIDANCE MATERIAL

Aircraft Maintenance Engineer Licence – Examination Module 16 – Compass Compensation

AMEL-EM16

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PREFACE

This Guidance Material (GM) is published by the Civil Aviation Authority of Fiji for purposes of promulgating supplementary material to that published in the Authority's Standards Documents.

This GM provides guidance to aircraft maintenance engineering personnel and CAAF staff on the acceptable means of compliance with the syllabus content in respect of written examinations for **Module 16 – Compass Compensation.**

This GM explains certain regulatory requirements by providing interpretive and explanatory material.

Chief Executive
Civil Aviation Authority of Fiji

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Table of Contents

ELIGIBILITY REQUIREMENTS **1**

EXAMINATION OVERVIEW: MODULE 16 ..... **1**

GENERAL EXAMINING OBJECTIVE 1
KNOWLEDGE LEVELS 1

RECOMMENDED STUDY MATERIAL **2**

PUBLICATION LIST 2

SYLLABUS LAYOUT **2**

TOPIC NUMBERING – LEFT HAND COLUMN 2
OBJECTIVE DESCRIPTION – MIDDLE COLUMN 3
KNOWLEDGE LEVELS – RIGHT HAND COLUMN 3

SYLLABUS: MODULE 16 – COMPASS COMPENSATION **4**

1. THEORY OF MAGNETISM 4
2. TERRESTRIAL MAGNETISM 5
3. AIRCRAFT MAGNETISM 5
4. THE COMPASS BASE 6
5. DIRECT READING MAGNETIC COMPASSES 8
6. THEORY OF COMPASS COMPENSATION 9
7. DIRECT READING COMPASS COMPENSATION PROCEDURE 11
8. REMOTE READING COMPASS SYSTEMS 12

Eligibility Requirements

ANR 53(2) requires an applicant for an AMEL to have passed written examinations, that areacceptable to the Authority, relevant to the duties and responsibilities of an aircraft maintenance engineer in the category of licence sought.

The written examinations acceptable to the Authority for Module 16 (Compass Compensation) should comply with the syllabus contained in this GM. 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: Module 16

Module 16 (Compass Compensation) is a closed book, written examination. The pass mark for Module 16 is 70 %.

NB: The examination contains a Swing Exercise (Topic 8.7) that consists of five questions that must be passed to gain a pass in Module 16.

An application to sit an examination may be made directly to ASPEQ. Refer to https://caaf.aspeqexams.com/home for examination information.

General Examining Objective

The objective of the examination is to determine that the applicant for an AMEL has adequate knowledge of Module 16 – Compass Compensation 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 should 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 should:

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	CAA AC 43-7	CAA of NZ	N/A
2	CAAUK CAP 562 Civil Aircraft Airworthiness Information and Procedures, Leaflets 34-10 & 34-20	CAAUK	N/A
3	Aircraft Instruments and integrated Systems	EHJ Pallett	0 582 08627 2
4	Avionic Fundamentals	Jeppesen	0-89100-293-6
5	A & P Technician Airframe Textbook	Jeppesen	0-88487-331-5
6	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 whichrefer 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 identifiedby 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: Module 16 – Compass Compensation

1. Theory of Magnetism		
1.1	**Nature of Magnetism** *Study Ref.2 & 7*	
1.1.1	Define or describe the following terms: a. Permanent magnet b. Bar magnet c. North and South seeking poles d. Magnetic attraction e. Magnetic repulsion f. Force of magnetic attraction or repulsion g. Hysteresis h. Magnetic field i. Magnetic field strength (H) j. Magnetic field force (F) k. Pole strength l. Magnetic material m. Magnetisation n. Like and unlike poles o. Attraction p. Magnetising force q. Lines of force r. Lines of flux and magnetic flux s. Concentration of flux t. Ferro magnetic substances u. Hard magnetism v. Soft magnetism w. Coercive force x. Reluctance y. Molecular theory of magnetism z. Magnetic screening aa. Symbol and unit for magnetic flux bb. Magnetic moment cc. Deflecting field dd. Magnetic couple ee. Period of a suspended magnet.	1
1.1.2	Describe the magnetic fields caused by permanent magnetism and the flow of electric current.	1
1.1.3	Trace the travel of magnetic lines of force both in air and through the core of a magnet.	1

2. Terrestrial Magnetism		
2.1	**Earth's Magnetic Field** *Study Refs. 2, 4 & 6*	
2.1.1	Define, using examples and diagrams, the following terms: a. Magnetic North and South poles b. True (Geographical) North c. Actual and hypothetical magnetic meridians d. Magnetic equator or aclinic line e. Horizontal component f. Angle of dip or magnetic inclination g. Positive and negative angles of dip h. Magnetic variation or declination i. Annual change j. Isoclinal lines k. Isogonal lines l. Agonic lines m. The significance of the red and the blue ends of a magnetic needle or compass pointer. n. Magnetic deviation.	1
2.1.2	State what happens to the red and the blue end of a magnetic needle as it transits from theNorth pole to the South pole.	1
2.1.3	Calculate true headings from magnetic headings and vice versa in both the Northern andSouthern hemispheres.	1
2.1.4	Describe the effects and nature of earth's magnetic lines of force as they travel between poles.	1
2.1.5	State how the strength of the earth's magnetic field varies at certain positions on the surface between the North and South poles.	1

3. Aircraft Magnetism		
3.1	**Magnetic Forces in an Aircraft** *Study Ref. 2*	
3.1.1	Define what magnetically "hard" and magnetically "soft" materials mean. Give examples of each material and where they might be found on aircraft.	2
3.1.2	Describe the cause and effects of sub-permanent magnetism.	2
3.1.3	Describe what happens with the application and removal of magnetising forces on hard and softmaterials.	2
3.1.4	Specify "soft iron" magnetism in an aircraft.	2
3.1.5	Describe "ability to be magnetised".	1

3.1.6	Describe the following: a. Sources of magnetising fields b. Polarities of magnetised components c. The effects of changing an aircraft's heading, attitude and position d. Resolution of horizontal and vertical components (H and Z forces) from the earth's magnetic field e. Resolution of X, Y and Z forces f. The effects of components P and Q g. Deviating forces on a compass needle.	2
3.1.7	Describe the cause and the effects on a compass system of the following errors: a. Acceleration error b. Turning error.	2
3.1.8	Define the term "Compass Safe Distance" and specify acceptable limits.	2
3.1.9	Specify how the direction of magnetisation of ferrous metal in an aircraft (with respect to the aircraft centre line) affects the compass deviation on respective headings.	2
3.1.10	Describe the cause and effect of changes in compass deviation during flight.	2
3.2	**Factors in selecting the location of a Compass** *Study Refs. 3 & 4*	
3.2.1	State the factors which must be taken into consideration when determining a suitable location and mounting for a compass, including the following: a. Position of moving steel components b. Electrical cables carrying uni-directional electrical currents c. Distance in feet away from electrical cables d. Generation of magnetic fields caused by electrical current passing through aircraft structure and instrument mounts e. The effects of modifications to electrical, instrument and radio systems.	2

4.	**The Compass Base**	
4.1	**Compass Base Requirements** *Study Refs. 1 & 3*	2
4.1.1	Specify the following requirements associated with the site selection, construction and maintenance of a compass base: a. Levelling of the base b. Magnetic disturbances above ground c. Magnetic disturbances below ground such as: scrap metal, reinforced concrete, pipelines and drainage systems, magnetic soil and rocks, electrical cables, conduits, airfield lighting transformers and ferromagnetic pipes d. Accessibility	

	e. Interference with other aircraft movements f. Size of base in proportion to aircraft size g. Towing and taxiing clearances h. Aircraft turning circles i. Position of heading points j. Position of the aircraft's sensors k. Effects of weather on base operations.	
4.2	**Base Classifications** *Study* Ref. 1	
4.2.1	State the deviation limits and the definition of a Class 1 base.	2
4.2.2	State the deviation limits and the definition of a Class 2 base.	2
4.2.3	Specify the reasons when a site should be re-surveyed.	2
4.2.4	Specify the re-survey intervals of a Class 1 and a Class 2 base.	2
4.2.5	Specify who would normally carry out a compass base survey or re-survey.	1
4.3	**Types of Survey** *Study Ref. 1*	
4.3.1	Describe the requirements, procedures and limitations of the following types of survey. Statethe differences between each: a. Initial Survey b. Establishment survey c. Periodic re-survey d. Annual check e. Area survey.	2
4.4	**Survey Methods** *Study Ref. 1*	
4.4.1	State the advantages of the following survey methods. State when each would be used: a. Reciprocal bearing method b. Distant bearing method c. Surveying pole method d. Magnetic intensity survey methods e. Area surveys.	2
4.5	**Checking and Correction of Survey Instruments**	
4.5.1	Describe the necessary checks and maintenance activities carried out on base survey equipmentprior to its use.	2
4.6	**Positioning of Surveying Equipment**	
4.6.1	Specify how surveying equipment is positioned during a base surveying operation.	2
4.7	**Reciprocal Bearing Survey Method**	
4.7.1	Describe the procedures, precautions, limits and recordings when carrying out a base surveyusing the reciprocal bearing method.	2

4.8	**Distant Bearing Survey Method**	
4.8.1	Describe the procedures, precautions, limits and recordings when carrying out a base surveyusing the distant bearing method.	2

5.	**Direct Reading Magnetic Compasses**	
5.1	**Compass Construction** *Study Ref. 4*	
5.1.1	Describe the construction and principles of operation of a card-type DR compass with particular regard to the following: a. Card and card markings b. Float c. Bowl d. Sensing magnet e. Expansion and contraction bellows f. Lubber line g. Lens h. Pivot i. Jewel j. Jewel post k. Jewel spring l. Compensating screws m. Compensating magnets.	1
5.1.2	Specify how magnetic deviation is physically compensated for in a DR compass.	2
5.1.3	State the cardinal and quadrantal points of a compass.	2
5.1.4	Describe the various mounting configurations for a card type compass.	1
5.1.5	Describe the following effects fluid in the compass bowl has on the operation of the compass: a. Damping b. Buoyancy c. Lubrication.	2
5.1.6	Define the term “aperiodic” as it relates to movement of the compass card.	2
5.1.7	Describe the type of fluid normally used in a DR compass bowl.	2
5.1.8	Specify why the magnetic system is made “pendulous”.	2
5.1.9	Distinguish the differences between a card type DR compass and a grid-steering type DRcompass.	2
5.2	**DR Compass Maintenance** *Study Ref. 3*	
5.2.1	Describe the following maintenance aspects relating to DR compasses: a. Normal compass location in the cockpit and the mounting arrangements includingaircraft structural considerations b. Type of hardware used to mount/secure the compass c. Materials used in the manufacture of tools used to service/adjust DR compasses.	2

5.2.2	Describe the pre installation checks on a compass with particular regard to the following: a. The glass, anti-vibration devices and moving parts b. Discolouration of the card and liquid c. Sediment and bubbles in the fluid d. Serviceability of compensator devices e. Operation of internal lighting where fitted.	2
5.2.3	Describe the pivot friction test with particular regard to: a. Position of the compass b. Means of deflection c. Deflection arc and time limit d. Limits specified for angular difference.	2
5.2.4	Describe the damping test with particular regard to the following: a. Deflection arc and time limit b. Deflection method c. Damping limits.	2
5.2.5	Specify the following conditions relating to the mounting of a compass: a. Position of the lubber line and vertical support relative to the axis of the aircraft b. Position of compensating devices relative to the location of the compass c. Position of the deviation or steer card d. Effects of electrical wiring on compass deviation.	2

6. Theory of Compass Compensation		
6.1	**Definitions** *Study Ref. 1*	
6.1.1	Identify the following factors relating to compass compensation: a. Coefficient A, B, and C b. Deviation c. Residual deviation d. Positive deviation e. Negative deviation f. Air swing g. Compensation h. Calibration.	2
6.2	**Basic Swing Theory** *Study Ref. 4*	
6.2.1	Specify the purpose of compensation.	2
6.2.2	Outline the four basic steps in carrying out a deviation compensation or compass swing.	2
6.2.3	Plot residual deviation D and E as a sine curve from zero to 360 degrees.	2
6.2.4	State the formulae for calculating coefficients A, B, and C.	2
6.2.5	Describe the <u>algebraic</u> summing of readings during the calculation of coefficients.	2

6.2.6	State the limits for residual deviation for both DR and RR compasses.	2
6.3	**Index error** *Study Ref. 3*	
6.3.1	Identify the following factors relating to index error: a. Index error relative to the axis of the aircraft b. Cause of index error c. Effects of index error on a heading d. Calculation of index error e. Compensation for index error.	2
6.4	**One-Cycle Errors** *Study Ref. 3*	
6.4.1	Describe the following: a. What is meant by one-cycle errors b. Cause of one-cycle errors c. Effects of one-cycle error on a heading d. Calculation of one-cycle error e. Compensation for one-cycle error.	2
6.5	**Occasions for Calibration** *Study Ref. 1*	
6.5.1	Specify the various out-of-phase occurrences when compass calibration should be carried out.	2
6.5.2	State the requirements and procedures for aircraft demagnetisation after a lightning strike.	2
6.5.3	State the aircraft operating and re-swinging requirements after aircraft demagnetisationfollowing a lightning strike.	2
6.5.4	Outline a simple heading check, when it may be carried out, and the coordinates used.	2
6.6	**Preparation Before Swinging** *Study Ref. 1 & 3*	
6.6.1	Specify the following activities that should be carried out before a compass swing: a. Installation of airborne equipment b. Loose items c. Tools made from magnetic materials d. Cockpit mechanical control locks e. Towing arms and towing vehicles f. Use of maintenance manuals for carrying out the swing g. Required equipment for the swing h. Landing gear ground locks i. Landing gear shock strut inflation j. Solenoid operated devices k. Position of flying controls l. Operation of electrical and avionic equipment m. Deviation compensator device settings after compass installation.	2

6.7	**Compass Serviceability Checks** *Study Ref. 3*	
6.7.1	Specify the following checks and limits relating to a DR compass prior to a compass swing: a. Readability of scales and graduations b. Bubbles in the fluid c. Liquid discolouration d. Security of mounting e. Presence of extraneous magnetic material f. Proximity of electrical wires or looms g. Pivot friction check h. Damping check.	2
6.8	**Aircraft Sighting Points** *Study Ref 3*	
6.8.1	Describe the following: a. Purpose of aircraft sighting points b. Location of aircraft sighting points including rods, plumb lines, target fixtures and otherdevices.	2

7. Direct Reading Compass Compensation Procedure		
7.1	**Checks at the Compass Swing Site** Study Ref. 1 & 3	
7.1.1	Describe the purpose of checks carried out at the compass swing site with respect to thefollowing: a. Movement of control surfaces b. Increase in engine power c. Operation of electrical, instrument or radio equipment.	2
7.1.2	Specify the compass swing requirements if operation of the above systems causes the compassdeviation to change.	2
7.2	**Coefficient Method** *Study Ref. 1*	
7.2.1	Outline the compass swing procedures using the coefficient method.	2
7.2.2	Describe the correcting swing and the check swing.	2
7.3	**Direct Correction Method** *Study Ref. 2*	
7.3.1	Outline the compass swing procedures using the direct correction method.	2
7.3.2	Describe the correcting swing and the check swing.	2
7.3.3	Describe the procedures for a final check on the accuracy of the swing.	2
7.4	**Compensation Procedure** *Study Ref. 3*	

7.4.1	Outline the following procedures relating to the calibration of a DR compass: a. Determining the history of the compass b. Preparation of the aircraft c. Communication with air traffic control or other airfield users d. Personnel requirements and interpersonal communications e. Positioning of the aircraft on the swing base f. Positioning of the landing compass g. Movement of the aircraft onto headings h. Use of aircraft sighting points i. Taking and recording of compass headings j. Calculation of coefficients A, B, C (As per AC43-7) k. Adjusting the compass for coefficients A, B, C l. Calculation of residual deviation m. Calculation of MCR n. Completion of a compass card o. Installation of compass card in the cockpit p. Times when a compass card is not required to be displayed q. Logbook recording r. Certification of the compass swing.	2
7.4.2	State the allowable tolerance when positioning an aircraft onto the required heading during a compass swing.	2

8.	**Remote Reading Compass Systems**	
8.1	**Theory of RR Compass Operation** *Study Ref. 5*	
8.1.1	Describe the principles of operation of a magnetic heading reference system (Remote Reading Compass) with particular regard to the following: a. The inductive element b. The horizontal component of the earth's magnetic field c. Flux d. Induced voltage changes e. Transmission to the heading indicator.	1
8.2	**Detector Element Construction** *Study Ref. 4 & 5*	
8.2.1	Define the following terms and modes of operation relating to RR compasses: a. Flux detectors b. Flux valves c. Nutation d. Null e. Synchronised f. Slaved g. Free.	2

8.2.2	Describe the components and construction of a detector element with particular regard to thefollowing: a. Spokes and spoke insulation b. Laminated collector horns c. Exciter (primary coil) d. Secondary pick-off coils e. Mounting flange f. Cover g. Bowl h. Pendulous weight.	2
8.2.4	State the purpose of a flux valve.	2
8.2.5	Describe the coil alignments that produce maximum and zero magnetic flux.	1
8.2.6	Show diagrammatically, flux versus angular position of a coil in a magnetic field (H).	2
8.2.7	Show diagrammatically exciter coil voltage in relation to the earth's magnetic field.	2
8.2.8	Describe the components, their interrelationship and principles of operation of a monitoredgyroscope system with particular regard to the following: a. Detector element b. Slaving/servo amplifier c. Directional gyro unit (DGU) d. Radiomagnetic indicator (RMI) e. Deviation compensator f. Transmission loop g. Control synchros.	1
8.2.9	Describe the type of current used to excite the detector in a remote indicating system.	2
8.2.10	Specify the purpose of the gyro in a slaved gyro-magnetic compass.	1
8.2.11	State how deviation errors are corrected in a slaved gyro-magnetic compass.	1
8.2.12	Specify why torque motors are used in some gyro-magnetic compass systems.	1
8.3	**RR Compass Installation and Maintenance** *Study Ref. 4*	
8.3.1	State how the rotor of a slaved gyro is automatically prevented from wandering in azimuth.	1
8.3.2	Specify where on an aircraft the detector unit in a RR compass system would normally belocated.	2
8.3.3	Describe the function of a follow-up system.	1
8.3.4	Describe the function of the DG flag on the gyro unit.	2
8.3.5	Specify the precautions to be taken during a continuity check on RR compass wiring.	2
8.3.6	Describe the mounting axis of the flux gate or flux valve.	2
8.3.7	State the other flight/navigation instruments with which a RR compass may be integrated.	2

8.3.8	Describe the cause and effect of static and dynamic errors in a RR compass system.	2
8.3.9	Specify where flux valve output is connected in a slaved gyro magnetic system.	2
8.3.10	Describe the information transmitted by the synchros in a RR compass system.	2
8.3.11	Describe the characteristics of a Gyrosyn system.	1
8.3.12	Describe items that would be checked during a typical routine periodic inspection of a RRcompass system.	1
8.4	**Swinging an RR Compass System** *Study Ref. 3*	
8.4.1	Identify the following principal errors that are associated with swinging a RR compass: a. Index errors b. One-cycle errors c. Two cycle errors d. Cross-talk errors.	2
8.4.2	Describe how Index error (coefficient A) compensation is carried out and how appropriateadjustments are made.	2
8.4.3	Describe how one-cycle error (coefficients B and C) compensation is carried out using thefollowing compensation methods: a. Mechanical Methods b. Electrical methods.	2
8.4.4	Describe how cross-talk error compensation is carried out.	2

8.5	**Conventional Swing Method** *Study Ref. 3*	
8.5.1	Describe the “conventional” compass swing procedure for a RR compass including the following activities: a. Selection of magnetic heading reference datum b. Limits for positioning an aircraft on a base heading c. Installation of sighting equipment d. Running of engines e. External power connections f. Synchronising of heading indicators against annunciator devices g. Slaving of compass system indicators h. Operational check of power failure warning devices i. Drift rate check of gyros j. Setting of deviation compensators k. Adjustment of permanent magnet and potentiometer compensator devices.	2
8.6	**Swinging by Inertial Navigation Systems** *Study Ref. 3*	
8.6.1	Outline the principles of swinging a compass using INS.	1

8.7	**Compensation Recording** *Study Ref. 3*	
8.7.1	Describe the completion of compass swing documentation with regard to logging of observedreadings, calculation of associated deviations and the applied corrections.	3
8.7.2	Complete a “Steer by” card.	3
8.8	**Compass Swinging in Service** *Study Ref. 3*	
8.8.1	State the occasions and procedures for carrying out an in-service RR compass swing.	2