021

AIRFRAMES & SYSTEMS, ELECTRICS, POWERPLANT, EMERGENCY EQUIPMENT

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
020 00 00 00	**AIRCRAFT GENERAL KNOWLEDGE**	
021 00 00 00	**AIRFRAME AND SYSTEMS, ELECTRICS, POWERPLANT, EMERGENCY EQUIPMENT - AIRCRAFT**	
021 01 00 00	**AIRFRAME AND SYSTEMS**	
021 01 08 00	**Air Driven systems (piston engines only)**	
021 01 08 04	**De-ice systems**	
	– Identify the location of pneumatic de-ice systems. – Name the categories of aeroplanes where these systems are installed. – Describe the working principle of the inflatable rubber boots. – State how the inflation and deflation is controlled. – Explain when the system should be operated. – State how the system is controlled and monitored.	
021 01 09 00	**Air driven systems (turbopropeller and jet aircraft)**	
021 01 09 03	**Anti-ice systems**	

	- Explain the difference between de-icing and anti-icing.
	- Describe when anti-ice systems have to be switched on.
	- Name the components of an aircraft that are protected from ice accretion by the use of bleed air.
	- Identify the components which constitute the anti-ice system and describe their function:
	  - pneumatic source
	  - shut-off valves
	  - pneumatic ducts
	  - perforated pneumatic ducts
		Given a schematic drawing of a anti-ice system.

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	- outflow holes under the wings or into the nacelles - Describe the operating principle of the anti-ice system. - Describe the two different operating principles of ice detectors. - Identify the monitoring instruments and controls of the anti-ice systems.	
021 01 10 00	**Non-pneumatic operated de-ice and anti-ice systems**	
021 01 10 01	**Schematic construction, function and operation** - Describe the construction, the operating principle and the operation of electric anti-icing of a propeller. - List other electrically ice protected aircraft components and describe their operation. - Explain the operating principle of the weeping wing system. - Explain the principle and method of operation of windshield rain protecting systems.	
021 02 00 00	**ELECTRICS**	
021 02 01 00	**Direct current (DC)**	
021 02 01 01	**General** – Electric circuits – Name examples of conductors, semiconductors and insulators. – State the relationship between voltage, current and resistance in a closed electrical circuit. – Name different types of switches.	

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	– State the purpose of the guard cap in the case of toggle switches. – State how the following devices work: thermo-, bimetallic-, time- and proximity-switches. – Voltage, current, resistance – Define voltage in words and state the relevant unit of measurement. – Define current in words and state the relevant unit of measurement. – Ohm's law – State Ohm's Law in qualitative terms. – Calculate voltage, current and resistance using Ohm's Law. – Resistive circuits – Calculate the total value of resistance in series and parallel circuits – Explain the relationship between individual voltages and current when resistors are connected in series. – Explain the relationship between individual currents and voltage when resistors are connected in parallel. – Resistance as a function of temperature – Define the change of resistance of a material as a function of temperature – State that resistances can have a positive temperature coefficient (PTC) or a negative temperature coefficient (NTC) – State that PTC and NTC resistors are used in aircraft systems for temperature measurement – Electrical power, electrical work – Define electrical power in qualitative terms and name the relevant unit of measurement – Define electrical work in qualitative terms and name the relevant unit of measurement.	

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	– Fuses, circuit breaker (function, type and operation) – Describe the method of operation of the circuit-breaker. – Explain how a fuse is rated – State the difference between a ”trip-free” and ”non-trip-free” circuit breaker. – State the methods of detecting failures in fuses and circuit-breakers. – List the different types of circuit breakers. – The electrical field – Define the term ”electrical field” in qualitative terms – State the difference between an electrical field and a magnetic field. – The capacitor (function) – State the principle of construction of a capacitor. – State how the capacitance (of a capacitor) is related to the plate area, the distance between the plates ,and the dielectric constant. – State, in qualitative terms, the alteration in total capacitance of capacitors when connected in series or in parallel.	
021 02 01 02	**Batteries** – Types, characteristics – State the components of a battery – Name the types of rechargeable batteries used in aircraft – For lead acid & NiCd batteries – describe the processes which occur during charging and discharging – differentiate between cell voltage and charging voltage	

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	– state the effect of temperature. – State the charging voltages which corresponds with different battery voltages. – Compare lead-acid and NiCd batteries in respect of voltage, load behaviour, self-discharge, thermal runaway and storage life – Capacity – Define the term ”capacity of batteries”. – State the relationship between voltage and capacity when batteries are connected in series or in parallel – Uses – List the uses of lead acid batteries and NiCd batteries. – Compare the relative advantages and disadvantages of lead acid and NiCd batteries – Hazards – State the dangers involved in overcharging lead-acid and NiCd batteries – Indicate the behaviour of NiCd batteries in the case of too high a temperature (thermal runaway). – Indicate why charging of lead-acid batteries with too high a voltage is dangerous – State that NiCd batteries are monitored to avoid damages resultant from excessive temperature increase	
021 02 01 03	**Magnetism** – Permanent magnetism – State the properties of a magnet. – Name the two poles of a permanent magnet – List the ferromagnetic materials that can be used for permanent magnets	

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	– State the direction of the magnetic flux outside the magnetic poles and inside the magnet – Electromagnetism – State that an electrical current produces a magnetic field around a conductor and define the direction of that field – Indicate how the strength of the magnetic field changes if supported by a ferromagnetic core – Explain the purpose of a relay – Name the components of a relay – Explain the purpose of a circuit breaker – Name the components of a circuit breaker – Explain how the coil circuit is insulated from the contact circuit – Explain the difference between a normally-open, a normally-closed and a changeover contact in a relay. – Electromagnetic power – State how the inductance of a coil depends on the number of windings, the cross-sectional area of the coil the coil length and the magnetic conductivity. – Electromagnetic induction – Explain the principle of electromagnetic induction. – State how the induced voltage in a coil depends on the number of windings, the magnetic flux and the rate of change of the magnetic flux	
021 02 01 04	**Generators** – Alternator – Principle, function and applications	

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	– Describe the condition for a voltage to be induced in a conductor. – Name the type of voltage which is induced in a rotating conductor loop in a homogeneous magnetic field – Name the components of a simple generator. – Define resonance. – State in qualitative terms how voltage depends on number of turns, field strength, rpm and load – Define the term ”internal-pole machine”. – Name the components of an alternator. – Compare the alternator and the simple generator with regard to: voltage response at low rpm power/weight ratio brush sparking current supply for the consumer AC-DC conversion – Describe the different generator switching possibilities in multiengine aircraft. – With regard to load distribution, compare and contrast the split system with the parallel system. – List the requirements to connect DC generators in parallel – Explain how control of load sharing is achieved when two DC generators are operating in parallel – Monitoring devices – Name different monitoring devices – Regulation, control and protection	

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	– Explain the principle of voltage control. – List the types of voltage regulators and explain their method of operation. – Explain why reverse current flow from the battery to the generator must be prevented. – Name the different types of reverse-current protection devices and explain how they work. – Describe the different alternator designs – Starter generator – Describe how the starter generator is constructed and indicate its purpose.	
021 02 01 05	**Distribution** – Current distribution (buses) – Explain the purpose of the bus – Name the purpose of the battery bus and of the hot bus – Name the components of the electrical power supply system used in flight – State the number of ammeters in a multi generator system – Use a block diagram to describe the supply system used in flight – Monitoring of electrical systems – State the methods of monitoring of electrical systems – Name the components of a moving-coil instrument – Explain the function of a moving-coil instrument – Explain the function of a Wheatstone Bridge – Ammeter, voltmeter – State the difference between a voltmeter and an ammeter with regard to resistance	Given appropriate diagram

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	– State the purpose of an ammeter and show how it is connected to the electrical load – State the purpose of a voltmeter and show how it is connected to the electrical load – Describe the possibilities for extending the measuring range of voltmeters and ammeters – Interpret the different ammeter indications of the ammeter which monitors the charge current of the battery. – Annunciators – Identify different types of annunciators. – Electrical consumers – List types of electrical consumers (loads) for an aircraft, and their different purposes: – lighting – heating – magnetic devices – avionics systems – instruments – Describe the components of a DC motor – Describe the circuitry for the field winding in the case of series, shunt, and compound wound motors. – Describe the RPM and torque behaviour of a series-wound motor and a shunt-wound motor as the load increases/decreases. – Explain how the direction of rotation of a DC motor can be changed. – Name typical applications for series and shunt field motor. – DC power distribution:	

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	– Construction, operation and system monitoring – Using simplified schematics, explain the construction of single- and multi-engined DC flight equipment – Using simplified schematics, show the effects of different switching operations. – Using simplified schematics, show the effects of the following cases: generator failure generator overloading overvoltage battery over/undercharge. – List the sources of external power supply. – List the significant points to be observed when operating with an external power supply. – State the effects on the progress of the flight if the generator or generator and battery fails. – State how fire, due to electrical causes, can be checked.	
021 02 01 06	**Inverter** – State the purpose of static inverters – List the parts used in the construction of a static inverter. – Describe the function of a static inverter. – State the commonly used output voltages of inverters – Name typical applications for an inverter.	
021 02 05 00	**<u>Basic radio propagation theory</u>**	
021 02 05 01	**Basic principles**	

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	- Electromagnetic waves
	  - List the bands of the frequency spectrum for electromagnetic waves.
	  - Define the following terms:
	  - superposition
	  - beat frequency
	  - fading
	  - mixture
	  - modulation
	- Wave length, amplitude, phase angle, frequency
	  - With reference to a sine wave, and using a line and vector diagram, define the following terms:
	  - amplitude
	  - angular frequency
	  - frequency
	  - wavelength
	  - Explain the relation between frequency, wavelength, and velocity of propagation.
	- Frequency bands, sideband, single sideband
	  - State the characteristics of the frequency bands.
	  - Identify typical applications for the frequency bands.
	  - Name the frequency band and corresponding wavelengths of different types of radio-electric equipment
	  - Define the term ”bandwidth”.
	  - State the relationship between bandwidth and minimum frequency spacing of transmitters.	

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	- State the relationship between bandwidth and minimum frequency spacing of receivers. - Explain how VHF communication is achieved. - Explain how HF communication is achieved. - Pulse characteristics - Define the following terms, as associated with a pulse string: - pulse length - pulse power - continuous power - Carrier, modulation, demodulation - Define the term ”Carrier Wave”. - Explain the purpose of a modulator and demodulator. - Types of modulation, (amplitude, frequency, pulse, multiplex) - Define the following types of modulation: - amplitude modulation (AM) - frequency modulation (FM) - pulse modulation, pulse coded modulation (PM, PCM) - State that FM modulation causes an increase in bandwidth if compared with AM. - Compare and contrast AM and FM with regard to interference and complexity of the equipment used. - List typical applications for AM, FM, PM. - State frequency range, channel spacing and type of modulation for a VHF-COM system. - Oscillation circuits	

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	- Explain the functional principle used in an oscillator. - Describe how an electrical resonant circuit is constructed. - Explain how a resonant circuit works. - Define the term ”resonant frequency”. - Define resonant frequency, bandwidth and selectivity. - Explain the piezo-electric effect in the case of a quartz crystal. - Compare and contrast an inductive/capacitive resonant circuit with a quartz crystal controlled resonant circuit with regard to frequency stability and frequency selection. - Name typical applications for inductive/capacitive resonant circuits and quartz crystal controlled resonant circuits. - Explain how capacitive reactance depends on the frequency. - Explain how the inductive reactance depends on the frequency. - Using diagrams, explain the functional principles involved in the magnetron and klystron. - Name typical applications for cathode ray tubes, magnetrons, klystrons. R/t airborne equipment Identify the task of a transmitter. Name the major components of a transmitter. Explain the purpose of an amplifier. Name types of amplifier. Explain the purpose of an oscillator. Explain the purpose of a channel selector. Explain the purpose of a frequency synthesizer.	

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	Explain the purpose of the power amplifier. Explain the purpose of a receiver. Name the main components of a receiver. Explain the purpose of filters. State that digital filters can be used in addition to as analog types. Explain the functional principles involved in: automatic volume control (AVC) automatic frequency control (AFC) squelch beat frequency oscillator (BFO) Explain the purpose of the audio selector panel. Name the components of an audio selector panel Explain the purpose of: crew interphone maintenance interphone cabin interphone Explain the purpose of the VHF communication system. List the components of a VHF-COM system Describe how the microphone selector switch, receiver selector switch and filter switch are operated Explain the purpose of the HF-COM system. List the components of an HF-COM system. State the range of an HF-COM system.	

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	State the purpose of the SELCAL system. List the components of a SELCAL system Explain the functional and operating principles involved in a SELCAL system Describe the task of an emergency locator transmitter. State the VHF and UHF emergency frequencies Identify the switch-on options for the emergency locator transmitter: Describe the technical construction and principal function of a GPS, including the satellite and airborne equipment.	
021 02 05 02	**Antennas** - Characteristics - Describe the current and voltage distribution for a dipole/monopole antenna - Define the term ”antenna diagram” or ”polar diagram”. - Draw the radiation diagram of a dipole. - Define the term ”loaded antenna” - List the different kinds of loaded antennas - Explain the skin effect in relation to frequency - Explain the bending of radio beams. - Define the terms ”parasitic antenna” and ”parasitic radiator”. - List causes of deflection of beams - Indicate the characteristics of the radiation diagram of glide-slope (GS) transmitters which may involve risks - Indicate the characteristics of the radiation pattern of the localizer (LOC) which may involve risks	

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	- State the difference between VOR and DVOR
	- Interpret the radiation pattern and polar diagram of the following ground equipment:
	  - marker
	  - glide-path transmitter, glideslope (GS)
	  - localizer (LOC)
	- Polarisation
	  - Define vertical and horizontal polarization.
	  - State that the antenna polarization is identical to the alignment of the antenna's electrical field component
	- Types of antennas
	  - Name the applications for different antenna arrays
	  - Illustrate the radiation patterns and applications for different antennas	

021 02 05 03	**Wave propagation** - State that, where the atmosphere is subject to intensified ionization due to solar radiation, the propagation range of a radio signal is affected. - List the factors that affect the degree of ionization. - Show how ionization intensities vary with time and altitudes. - List the layers of the ionosphere by height and diurnal variation. - State the reasons for frequency-dependent physical phenomena of electromagnetic waves - Explain the connection between frequency and range. - Ground waves - Define 'ground wave'	Given appropriate diagram

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	- Define ‘skip zone’ and ‘skip distance’ - Space waves - Define ‘sky wave’ - Propagation with the frequency bands - State how VHF and higher frequencies are propagated - Calculate the reception range for VHF frequencies. - State the reasons why ranges may vary from those expected. - State the range of ground waves in the HF band. - State that multiple reflections (from the ionized layers) can result in such large ranges that worldwide communication is possible - Name the ionized layer which absorbs frequencies in the LF/MF band. - State that the range of the ground wave is greater over water than over land, and is also significantly affected by the transmitting power - State that the range in this band is increased at twilight and at night - State that radio waves in the VLF band propagate between the surface of the Earth and the ionosphere like a wave guide - State that the range permits global coverage if the transmitter is sufficiently powerful. - Frequency prognosis (prediction, MUF) - List the ranges of frequencies of the different navigational aids - Fading - Explain the reason for fading. - Factors affecting propagation (reflection, absorption, interference, twilight)	

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	- State that the direction of propagation is altered by refraction at shore-lines. - State that there may be reflections by terrain elevations, buildings, etc., leading to multi-path propagation effects - Shoreline, mountain, static - List bearing errors arising from atmospheric disturbances, and explain their causes and effects	