

D. SUBJECT 031 — MASS AND BALANCE**(1) MASS DEFINITIONS***Allowed take-off mass*

The mass taking into consideration all possible limitations for take-off including restrictions caused by regulated take-off mass and regulated landing mass.

Area load or floor load

The load (or mass) distributed over a defined area. Units of measurement used:

SI: N/m^2 , kg/m^2 ;

Non-SI: psi, lb/ft^2 .

Basic empty mass

The mass of an aircraft plus standard items such as: unusable fuel; full operating fluids; fire extinguishers; emergency oxygen equipment. (The lowest mass that is used in FCL exams.)

Dry operating mass

The total mass of an aircraft ready for a specific type of operation excluding all usable fuel and traffic load. This mass includes items such as:

- crew and crew baggage;
- catering and removable passenger service equipment (food, beverages, potable water, lavatory chemicals, etc.);
- special operational equipment (e.g. stretchers, rescue hoist, cargo sling).

In-flight mass

The mass of an aircraft in flight at a specified time.

Landing mass

The mass of the aircraft at landing.

Maximum structural in-flight mass with external loads (applicable to helicopters only)

The maximum permissible total mass of the helicopter with external loads.

Maximum structural landing mass

The maximum permissible total mass of the aircraft at landing under normal circumstances.

Maximum structural mass

The maximum permissible total mass of the aircraft at any time. It will be given only if there is no difference between maximum structural taxi mass, maximum structural take-off mass and maximum structural landing mass.

Maximum structural take-off mass

The maximum permissible total mass of the aircraft at commencement of take-off.

Maximum (structural) taxi mass or maximum (structural) ramp mass

The maximum permissible total mass of the aircraft at commencement of taxiing.

Minimum mass (applicable to helicopters only)

The minimum permissible total mass for specific helicopter operations.

Operating mass

The dry operating mass plus fuel but without traffic load.

Performance-limited landing mass

The mass subject to the destination airfield limitations. It must never exceed the maximum structural limit.

Performance-limited take-off mass

The take-off mass subject to departure airfield limitations. It must never exceed the maximum structural limit.

Ramp mass (see taxiing mass)

Regulated landing mass

The lower of performance-limited landing mass and maximum structural landing mass.

Regulated take-off mass

The lower of performance limited take-off mass and maximum structural take-off mass.

Running (or linear) load

The load (or mass) distributed over a defined length of a cargo compartment irrespective of load width. Units of measurement used:

SI: N/m, kg/m;

Non-SI: lb/in, lb/ft.

Take-off fuel

The total amount of usable fuel at take-off.

Take-off mass

The mass of the aircraft including everything and everyone contained in it at the commencement of take-off.

Taxi mass or ramp mass

The mass of the aircraft at the commencement of taxiing.

Traffic load

The total mass of passengers, baggage and cargo including any non-revenue load.

Zero-fuel mass

The dry operating mass plus traffic load but excluding fuel.

Syllabus reference	Syllabus details details and associated Learning Objectives	Aeroplane		Helicopter		IR
		ATPL	CPL	ATPL/IR	ATPL	
030 00 00 00	FLIGHT PERFORMANCE AND PLANNING					
031 00 00 00	MASS AND BALANCE — AEROPLANES/HELICOPTERS					
031 01 00 00	PURPOSE OF MASS-AND-BALANCE CONSIDERATIONS					
031 01 01 00	Mass limitations					
031 01 01 01	Importance with regard to structural limitations					
	LO Describe the relationship between aircraft mass and structural stress. <i>Remark: See also 021 01 01 00.</i>	x	x	x	x	x
	LO Describe that mass must be limited to ensure adequate margins of strength.	x	x	x	x	x
031 01 01 02	Importance with regard to performance <i>Remark: See also subjects 032/034 and 081/082.</i>					
	LO Describe the relationship between aircraft mass and performance.	x	x	x	x	x
	LO Describe that aircraft mass must be limited to ensure adequate aircraft performance.	x	x	x	x	x
	LO Describe that the actual aircraft mass must be known during flight as the basis for performance-related decisions.	x	x	x	x	x
031 01 02 00	Centre-of-gravity (CG) limitations					
031 01 02 01	Importance with regard to stability and controllability Remark: See also subjects 081/082.					
	LO Describe the relationship between CG position and stability/controllability of the aircraft.	x	x	x	x	
	LO Describe the consequences if CG is in front of the forward limit.	x	x	x	x	x
	LO Describe the consequences if CG is behind the aft limit.	x	x	x	x	x

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031 01 02 02	Importance with regard to performance <i>Remark: See also subjects 032/034 and 081/082.</i>						
LO	Describe the relationship between CG position and aircraft performance.	x	x	x	x		
LO	Describe the effects of CG position on performance parameters (speeds, altitude, endurance and range).	x	x	x	x	x	
031 02 00 00	LOADING						
031 02 01 00	Terminology						
031 02 01 01	Mass terms						
LO	Define the following mass terms: — basic empty mass; — dry operating mass; — operating mass; — take-off mass; — landing mass; — ramp/taxiing mass; — in-flight mass (gross mass); — zero-fuel mass.	x	x	x	x	x	
031 02 01 02	Load terms (including fuel terms) <i>Remark: See also subject 033.</i>						
LO	Define the following load terms: — payload/traffic load; — block fuel; — taxiing fuel; — take-off fuel; — trip fuel; — reserve fuel (contingency, alternate, final reserve and additional fuel); — extra fuel.	x	x	x	x	x	
LO	Explain the relationship between the various load-and-mass components listed above.	x	x	x	x	x	
LO	Calculate the mass of particular components from other given components.	x	x	x	x	x	

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		ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Convert fuel mass, volume and density given in different units used in aviation.	X	X	X	X	X	
031 02 02 00	Mass limits						
031 02 02 01	Structural limitations						
LO	Define the following structural limitations:	X	X	X	X	X	
LO	Maximum zero-fuel mass.	X					
LO	Maximum ramp/taxiing mass.	X					
LO	Maximum take-off mass.	X	X	X	X	X	
LO	Maximum in-flight (gross) mass.	X	X	X	X	X	
LO	Maximum in-flight (gross) mass with external load.			X	X	X	
LO	Maximum landing mass.	X	X	X	X	X	
031 02 02 02	Performance limitations						
LO	Define the following performance limitations: — performance-limited take-off mass; — performance-limited landing mass; — regulated take-off mass; — regulated landing mass.	X	X	X	X	X	
031 02 02 03	Cargo-compartment limitations						
LO	Define the following cargo-compartment limitations:	X	X	X	X	X	
LO	Maximum floor load (maximum load per unit of area).	X	X	X	X	X	
LO	Maximum running load (maximum load per unit of fuselage length).	X	X	X	X	X	
031 02 03 00	Mass calculations						
031 02 03 01	Maximum masses for take-off and landing						
LO	Calculate the maximum mass for take-off (regulated take-off mass) given mass-and-load components and structural/performance limits.	X	X	X	X		

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		ATPL	CPL	ATPL/IR	ATPL	
LO	Calculate the maximum mass for landing (regulated landing mass) given mass-and-load components and structural/performance limits.	X	X	X	X	
LO	Calculate the allowed mass for take-off.	X	X	X	X	
031 02 03 02	Allowed traffic load and fuel load					
LO	Calculate the maximum allowed traffic load and fuel load in order not to exceed the given allowed take-off mass.	X	X	X	X	X
LO	Calculate 'under load'/'over load' given allowed mass for take-off, operating mass and actual traffic load.	X	X	X	X	X
031 02 03 03	Use of standard masses for passengers, baggage and crew					
LO	Extract the appropriate standard masses for passengers, baggage and crew from relevant documents or operator requirements.	X	X	X	X	X
LO	Calculate the traffic load by using standard masses.	X	X	X	X	X
031 03 00 00	FUNDAMENTALS OF CENTRE-OF-GRAVITY CALCULATIONS					
031 03 01 00	Definition of Centre of Gravity (CG)					
LO	Define and explain the meaning of 'CG'.	X	X	X	X	X
031 03 02 00	Conditions of equilibrium (balance of forces and balance of moments)					
LO	Define 'datum' (reference point), 'moment arm' and 'moment'.	X	X	X	X	X
LO	Name the conditions of equilibrium.	X	X	X	X	X
031 03 03 00	Basic calculations of CG					
LO	Resolve numerical problems using the principle of equilibrium of forces and moments.	X	X	X	X	X

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		ATPL	CPL	ATPL/IR	ATPL	
031 04 00 00	MASS-AND-BALANCE DETAILS OF AIRCRAFT					
031 04 01 00	Contents of mass-and-balance documentation					
031 04 01 01	Datum, moment arm					
	LO Name where the datum and moment arms for aircraft can be found.	x	x	x	x	x
	LO Extract the appropriate data from given documents.	x	x	x	x	x
031 04 01 02	CG position as distance from datum					
	LO Name where the CG position for an aircraft at basic empty mass can be found.	x	x	x	x	x
	LO Name where the CG limits for an aircraft can be found.	x	x	x	x	x
	LO Extract the CG limits from given aircraft documents.	x	x	x	x	x
	LO State the different forms in presenting CG position as distance from datum or other references.	x	x	x	x	x
031 04 01 03	CG position as percentage of Mean Aerodynamic Chord (% MAC) <i>Remark: Knowledge of the definition of MAC is covered under reference 081 01 01 05.</i>					
	LO Extract % MAC information from aircraft documents.	x	x			
	LO Explain the principle of using % MAC for the description of the CG position.	x	x			
	LO Calculate the CG position as % MAC.	x	x			
031 04 01 04	Longitudinal CG limits					
	LO Extract the appropriate data from given sample documents.	x	x	x	x	x
031 04 01 05	Lateral CG limits					

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LO	Extract the appropriate data from given sample documents.			X	X	X	
031 04 01 06	Details of passenger and cargo compartments						
LO	Extract the appropriate data (e.g. seating schemes, compartment dimensions and limitations) from given sample documents.	X	X	X	X	X	X
031 04 01 07	Details of fuel system relevant to mass-and-balance considerations						
LO	Extract the appropriate data (e.g. fuel-tank capacities and fuel-tank positions) from given sample documents.	X	X	X	X	X	X
031 04 02 00	Determination of aircraft empty mass and CG position by weighing						
031 04 02 01	Weighing of aircraft (general aspects)						
LO	Explain the general procedure and regulations for weighing of aircraft (conditions, intervals, reasons and requirements for reweighing). <i>Remark: See the applicable operational requirements.</i>	X	X	X	X	X	
LO	Extract and interpret entries from/in 'mass (weight) report' of an aircraft.	X	X	X	X	X	
031 04 02 02	Calculation of mass and CG position of an aircraft using weighing data						
LO	Calculate the mass and CG position of an aircraft from given reaction forces on jacking points.	X	X	X	X	X	
031 04 03 00	Extraction of basic empty mass and CG data from aircraft documentation						
031 04 03 01	Basic empty mass (BEM) and/or dry operating mass (DOM)						
LO	Extract values for BEM and/or DOM from given documents.	X	X	X	X	X	
031 04 03 02	CG position and/or moment at BEM/DOM						

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LO	Extract values for CG position and moment at BEM and/or DOM from given documents.	X	X	X	X	X
031 04 03 03	Deviations from standard configuration					
LO	Extract values from given documents for deviation from standard configuration as a result of varying crew, optional equipment, optional fuel tanks, etc.	X	X	X	X	X
031 05 00 00	DETERMINATION OF CG POSITION					
031 05 01 00	Methods					
031 05 01 01	Arithmetic method					
LO	Calculate the CG position of aircraft by using the formula: CG position = sum of moments/total mass.	X	X	X	X	X
031 05 01 02	Graphic method					
LO	Determine the CG position of aircraft by using the loading graphs given in sample documents.	X	X	X	X	X
031 05 01 03	Index method					
LO	Explain the principle of the index method.	X	X	X	X	X
LO	Define the terms 'index', 'loaded index' and 'dry operating index'.	X	X	X	X	X
LO	State the advantage(s) of the index method.	X	X	X	X	X
031 05 02 00	Load and trim sheet					
031 05 02 01	General considerations					
LO	Explain the principle and the purpose of load sheets.	X				
LO	Explain the principle and the purpose of trim sheets.	X				
031 05 02 02	Load sheet and CG envelope for light aeroplanes and for helicopters					

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		ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Add loading data and calculate masses in a sample load sheet.	X	X	X	X	X	
LO	Calculate moments and CG positions.	X	X	X	X	X	
LO	Check CG position at zero-fuel mass and take-off mass to be within the CG envelope including last-minute changes, if applicable.	X	X	X	X	X	
031 05 02 03	Load sheet for large aeroplanes						
LO	Explain the purpose of load-sheet sections and the methods for establishing 'allowed mass for take-off', 'allowed traffic load' and 'under load'.	X					
LO	Explain the purpose of load-sheet sections and the methods for assessing load distribution.	X					
LO	Explain the purpose of load-sheet sections and methods for cross-checking the actual and limiting mass values.	X					
LO	Calculate and/or complete a sample load sheet.	X					
031 05 02 04	Trim sheet for large aeroplanes						
LO	Explain the purpose of the trim sheet and the methods to determine the CG position.	X					
LO	Check that the zero-fuel mass index is within the limits.	X					
LO	Determine the fuel index by using the 'fuel index correction table' and determine the CG position as % MAC.	X					
LO	Check that the take-off mass index is within the limits.	X					
LO	Determine 'stabiliser trim units' for take-off.	X					
LO	Explain the difference between certified and operational CG limits.	X					
031 05 02 05	Last-minute changes						

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	LO Complete a load and trim sheet for last-minute changes.	X					
031 05 03 01	Repositioning of CG by shifting the load						
	LO Calculate the mass to be moved over a given distance, or to/from given compartments, to establish a defined CG position.	X	X	X	X	X	
	LO Calculate the distance to move a given mass to establish a defined CG position.	X	X	X	X	X	
031 05 03 02	Repositioning of CG by additional load or ballast						
	LO Calculate the amount of additional load or ballast to be loaded at a given position or compartment to establish a defined CG position.	X	X	X	X	X	
	LO Calculate the loading position or compartment for a given amount of additional load or ballast to establish a defined CG position.	X	X	X	X	X	
031 06 00 00	CARGO HANDLING						
031 06 01 00	Types of cargo (general aspects)						
	LO Explain the basic idea of typical types of cargo, e.g. containerised cargo, palletised cargo, bulk cargo.	X	X	X	X	X	
031 06 02 00	Floor-area load and running-load limitations in cargo compartments						
	LO Calculate the required floor-contact area for a given load to avoid exceeding the maximum permissible floor load of a cargo compartment.	X	X	X	X	X	
	LO Calculate the maximum mass of a container with given floor-contact area to avoid exceeding the maximum permissible floor load of a cargo compartment.	X	X	X	X	X	

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		ATPL	CPL	ATPL/IR	ATPL		CPL
LO	Calculate the linear load distribution of a container to avoid exceeding the maximum permissible running load.	X	X	X	X	X	
031 06 03 00	Securement of load						
LO	Explain the reasons for having an adequate tie-down of loads.	X	X	X	X	X	
LO	Name the basic methods for securing loads.	X	X	X	X	X	