## 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 | CPL | |
| **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.<br>*Remark: See also 021 01 01 00.* | 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**<br>*Remark: See also subjects 032/034 and 081/082.* | | | | | | |
| 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**<br>**031 01 02 01** | **Centre-of-gravity (CG) limitations**<br>**Importance with regard to stability and controllability**<br>**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**<br>*Remark: See also subjects 032/034 and 081/082.* | | | | | | |
| 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:<br>— basic empty mass;<br>— dry operating mass;<br>— operating mass;<br>— take-off mass;<br>— landing mass;<br>— ramp/taxiing mass;<br>— in-flight mass (gross mass);<br>— zero-fuel mass. | x | x | x | x | x | |
| **031 02 01 02** | **Load terms (including fuel terms)**<br>*Remark: See also subject 033.* | | | | | | |
| LO | Define the following load terms:<br>— payload/traffic load;<br>— block fuel;<br>— taxiing fuel;<br>— take-off fuel;<br>— trip fuel;<br>— reserve fuel (contingency, alternate, final reserve and additional fuel);<br>— 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:<br>— performance-limited take-off mass;<br>— performance-limited landing mass;<br>— regulated take-off mass;<br>— 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 | CPL | |
| 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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|---|---|---|---|---|---|---|---|
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| **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)**<br>*Remark: Knowledge of the definition of MAC is covered under reference 081 01 01 05.* | | | | | | |
| 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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| | | ATPL | CPL | ATPL/ IR | ATPL | CPL | |
| 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).<br>*Remark: See the applicable operational requirements.* | 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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| | | ATPL | CPL | ATPL/ IR | ATPL | CPL | |
| 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:<br>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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|---|---|---|---|---|---|---|---|
| | | ATPL | CPL | ATPL/ IR | ATPL | CPL | |
| 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 | |