Aircraft Design 1

Assignment 2: Preliminary & Propulsion Sizing

Grading scale:

|  |  |  |
| --- | --- | --- |
| **Grade** | **Evaluation** | **Equivalent grade/10** |
| 1 | Excellent | 10 |
| 2 | Good | 9 |
| 3 | Satisfactory | 8 |
| 4 | Insufficient | No grade |

Your overall grade was calculated by averaging the components in each numbered item. If your overall report was insufficient, a resubmission is necessary to correct the shortcomings and obtain a grade. If individual items are a 4, it is highly recommended to update them or review them as needed with the provided feedback in your assignment file. Penalties (0.5pts each) were applied for late submissions, or submissions with an incorrect filename or filetype.

|  |  |  |
| --- | --- | --- |
|  | Group |  |
|  | Overall assignment grade |  |
|  | Submission # |  |
| **1** | Preliminary Sizing & Performance |  |
|  | Non-fuel intensive flight section fuel fraction estimation |  |
|  | Fuel intensive flight section estimations (loiter & cruise) |  |
|  | Estimation of the take-off weight (graph) of aircraft and comparison to other aircraft |  |
|  | Total weight estimation |  |
|  | Stall sizing |  |
|  | Take-off sizing |  |
|  | Landing sizing |  |
|  | Drag polar for in the most relevant flight conditions (cruise, landing, take-off, approach) |  |
|  | Climb performance sizing (c) |  |
|  | Climb gradient sizing (c/v) |  |
|  | T/W-W/S or W/P-W/S diagram (graph) and selection of the “optimum” design point |  |
| **2** | Preliminary Engine Sizing |  |
|  | Thrust requirements from regulations (OEI/AEO) |  |
|  | Engine references |  |
|  | Selected engine with explanation of selection process |  |
|  | Engine scaling |  |
|  | Fuel check for selected/scaled engine |  |
|  | Aircraft payload check on basis of fuel and engine weight |  |
|  | Suggestions on engine improvements |  |
| **3** | General Report Quality |  |
|  | ABS - Specificity of the report to the design |  |
|  | Template/layout |  |
|  | Appropriate level of detail |  |
|  | Indication and use of units |  |
| **4** | **Submission Penalty (-0.5pts each)** |  |
|  | Submitted late (number of days late) |  |
|  | Incorrect filename |  |
|  | Incorrect file format (PDF only) |  |

# Preliminary Sizing & Performance

The perform a preliminary sizing for your aircraft:

* Estimate the take-off weight of your aircraft and compare this to other aircraft in the category (graph)
* Estimate the drag polar for your aircraft in the most relevant flight conditions (T/O-Cruise-Landing)
* Develop a T/W-W/S (for jets) or W/P-W/S (for propellers) diagram for your aircraft and choose the “optimum” design point. Use a clear legend, with easily distinctionable linestyles and colors to annotate the graph.

# Preliminary Engine Sizing

Make a selection of the engine type, dimensions and weight based on the requirements at relevant flight conditions (e.g. take-off, cruise) and the preliminary sizing performed. The starting point will be the maximum thrust (jet engine), or power (propeller engine) as calculated above. For multi-engine aircraft you must consider the multi-engine regulations, such as T/O with one engine off.

The following propulsion sizing process must be followed, as instructed in the lecture notes:

* Define the required thrust (in kN for jet propulsion) or power (in propeller shaft kW or HP for propeller aircraft) for the aircraft you designed, for T/O, climb and cruise. Give both the values for the aircraft in total and per engine. Note that the selection of number of engines may be changed later depending on the available engines.
  + For jet propulsion:
    - Use references to select existing engines (preferably 3 or 4) that best fit the thrust requirements, and list as much information as possible, including manufacturer and engine type, thrust, specific fuel consumption at the defined flight condition(s), engine outer diameter (to fit your aircraft lay-out) and weight. Justify why these engines would suit your application, and how far they deviate from the specified requirements.
  + For propellor propulsion:
    - Estimate the necessary engine power (hp of kW). Select existing piston engines or gas turbines (preferably 3 or 4), that best fit the power requirements, and list as much as possible information, like manufacturer and engine type, power, specific fuel consumption at the defined flight condition(s) and weight. Justify why these engines would suit your application, and how far they deviate from the specified requirements.
* Select the engine that is closest to the requirements of your application and motivate your choice.
* List as much as information possible on the selected engine (at least specified thrust or power of the engine at T/O and cruise, from reference sources such as the manufacturers website, and compare with your numbers for your own aircraft (show selected engine’s data and your requirements in a table).
* “Scale” the engine to your needs, as depicted in the book “Design of Aircraft” by Thomas C. Corke. (Table with original numbers and resulting scaled values for thrust, diameter, length, weight and sfc). These rules are explained in the lecture slides.
* Check the amount of fuel necessary for the specified range (using the Breguet equations for endurance and range during the fuel-intensive flight phases). If there is a significant difference (more than 10%) between the outcome of this and what was estimated in assignment 2.1, redo the preliminary sizing as was performed in assignment 2.1 with the updated fuel weight values for fuel-intensive flight phases.
* Check the payload of your aircraft based on fuel weight and engine weight.
* Propose improvements on specific fuel consumption that the manufacturer could consider, by improving the engine thermodynamic cycle (suggest at least three improvements)

For all subparts show only the relevant calculations and outcome and minimize the narrative.

**Maximum size: 20 pages in total (Min. font 12 pt), excluding references and appendices.**

# General notes

* **ABS (Always Be Specific)**: Focus the discussion on your specific aircraft and design, do not discuss aircraft/spacecraft projects in general, but it is ok to refer to typical designs for comparison.
* **ABC (Always Be Concise)**: Be concise. Always justify & discuss your statements in a clear but concise way. Describe figures, tables, graphs and trendlines and refer to them in the text (no floating figures). Introduction, abstract, acknowledgement sections, etc., are not required.
* **Properly reference** your sources; use IEEE or AIAA engineering reference styles. Ensure all figures/tables/graphs/diagrams have descriptive captions and labels/numbers that are referred to in the body of the text. Make appropriate use of literature data. When using work from others, always include detailed references. Plagiarism and straight copying of work is a USC honour code violation and will be reported!
* Treat this as a full engineering report: there must be a minimal narrative explaining the design decisions and report graphs, not simply a compilation of images and graphs there is no need to re-derive equations; but show your values used/calculated (ABS/ABC).
* **RTFM** (**Read the assignment twice**): Make use of the document template provided on blackboard. You are allowed to use your own template as long as it contains the same elements as the provided template. Add relevant oversized additional information (technical drawings, flow charts) in appendices. Do not forget the required Appendixes! Appendices do not count towards the page limit.
* When using drawings, schematics and images, make sure they are **clearly readable**. Produce good quality drawings **(annotated and to scale**). Hand drawings are acceptable for concept sketches, but only **CAD drawings** are acceptable for the final concept!
* Remember: the required level of detail is that of conceptual design (check the number of decimals in your drawings annotations!)
* Remove any unneeded white space in all images.
* Make appropriate use of literature data and airworthiness regulations (always include detailed references). For military or UAV aircraft refer, when possible, to the civil airworthiness regulations that matches your type of aircraft the best (unless you can find appropriate information in literature).
* It is not expected to have any accurate shaping of wing and empennages. However, make sure to indicate in the drawings their intersection with the fuselage.
* Make smart use of tables, equations and graphs to present the system and narrate your work, and use appropriate captions.
* Make proper use of version control and submit using the requested filename convention.
* Use a spelling/grammar checker to verify your work!
* For military or UAV aircraft refer, when possible, to the civil airworthiness regulations that matches your type of aircraft the best (unless you can find appropriate information in literature).
* **Pay attention to units**! DON’T mix different units and/or different unit systems (or include both).
* Assignment examples provided (if any) are examples of work that was graded “good” or “excellent”, and may contain errors. Use/reference at your own risk.
* **Remember to indicate the approximate time you spent working on the assignment (do not include the time spent learning Word, Excel, LaTeX, CAD systems, etc.)**