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**During the exam it is not possible to look at any study material, notes, slides, textbook, etc.**

**You can only make use of a normal calculator and the formula sheet provided in class.**

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You are an engineer at AeroIndustries, conceptual development group.
Together with your colleagues, you are currently busy developing a new 200 passenger jet aircraft, which must be able to cover a cruise range of 10000 Km with maximum payload.
Your first task is to compute the **cruise fuel fraction** (i.e. the ratio between the aircraft weight at the end of the cruise segment and its weight at the beginning of the cruise).
These are the data you have available at hand so far (some have been estimated by your colleagues, some are requirements from the customer):

Passengers: 200 in single class (90 Kg per pax including luggage)
Cruise speed: 250 m/s at an altitude of 10000m
Loiter time: 45 minutes
Specific fuel consumption Cj : 0.00001415 Kg/Ns
Cruise aerodynamic efficiency: 15
Maximum landing/takeoff weight: 0.85
Take off and landing distance: 2000m

Your second task is to investigate the potential benefit in term of weight reduction of some technology improvements. In particular you have to evaluate whether it is more convenient to **improve the aerodynamic efficiency** of your aircraft by **10%** or try to obtain from the engine manufacturer a propulsive system with a **5% lower specific fuel**. Of course you will have to substantiate your evaluation with some calculation.

**Answer:**
A lot of the data provided above are not necessary to compute the cruise fuel fraction. The Brequet range equation will be sufficient:

$$R = \left(\frac{V}{g.c_j}\right)_{cruise} \cdot \left(\frac{L}{D}\right)_{cruise} \ln\left(\frac{W_4}{W_5}\right)$$

10000*1000=250/(0.00001415*9.80665)*15*X
X=0.370
W4/W5 = exp X = 1.448
W5/W4 = 0.691

W5/W4 = 0.714 in case of L/D=16.5 (10% higher)

W5/W4 = 0.704 in case of Cj=1.344*10^-5 Kg/Ns (5% lower)

The 10% increase in aerodynamic efficiency has a more beneficial effect than the 5% decrease in specific fuel consumption. In fact the amount of fuel that would be required for the cruise phase is smaller (the cruise fuel fraction W5/W4 is higher).

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Based on the table below from CS25, define the **type and minimum amount** of emergency exits for a 300 passenger aircraft.

| No. Pass. | Type I | Type II | Type III | Type IV |
|---|---|---|---|---|
| 1–9 | | | | 1 |
| 10–19 | | | 1 | |
| 20–39 | | 1 | 1 | |
| 40–79 | 1 | | 1 | |
| 80–109 | 1 | | 2 | |
| 110–139 | 2 | | 1 | |
| 140–179 | 2 | | 2 | |
| 180–299 | Add exits so that 179 plus "seat credits" ≥ passenger number. | | | |
| | Seat Credit | | Exit Type | |
| | 12 | | Single Ventral | |
| | 15 | | Single Tailcone | |
| | 35 | | Pair Type III | |
| | 40 | | Pair Type II | |
| | 45 | | Pair Type I | |
| | 110 | | Pair Type A | |
| ≥ 300 | Use pairs of Type A or Type I with the sum of "seat credits" ≥ passenger number. | | | |

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**Answer:**
**All Type A or Type I doors should be used based on the seat credit systems (110 pax per pair of door A, 45 pax per pair of Type I). The minimum amount of doors can be obviously achieved using 300/110 pairs of type A doors.**
**3 pairs of Type A door, i.e. 3 Type A door per side, will suffice.**

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Looking at the main ingredients required to build a trade off table, the following are required:

1. Trade off criteria, weights, functions, scores
2. Trade off functions, scores, concepts, top level requirements
3. **Weights, trade off criteria, scores, concepts to be traded off**
4. Drawings, Functional analysis, trade off requirements
5. None of the groups above is either correct or complete. The correct ingredients are actually the followings: ……………………….

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Which one of the statements below is wrong?

1. The required overnose angle is related to the approach speed of the aircraft
2. The tail cone angle of the fuselage (also called divergence angle) should be smaller than 24 degrees to allow good aerodynamic performance
3. The so-called aircraft rotation angle depends on the main landing gear position of the aircraft
4. **The overside angle determines the side stability of the aircraft on the ground**
5. The grazing angle depends on the inclination of cockpit windshield

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Why it is not possible for a given aircraft to fulfill at the same time the requirements of maximum payload and maximum range?

1. Actually it would be technically possible, but airworthiness regulations would not allow
2. Actually it would be possible but the fuel consumption would be too high
3. Actually it is possible for ferry operations
4. **It is not possible because limits on maximum take off weight require trading off payload and fuel**
5. It is not possible because limits on maximum take off weight require trading off fuel weight and harmonic range

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In the sizing process of a propeller aircraft it is generally convenient to have:

1. The highest value of power loading (W/P) and lowest value of wing loading (W/S)
2. The lowest value of power loading (W/P) and the lowest value of wing loading (W/S)
3. **The highest value of power loading (W/P) and the highest value of wing loading (W/S)**
4. A linear relation between the power loading and the wing loading
5. A wing loading and power loading compliant with the values stipulated by regulations

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During the preliminary sizing of an aircraft (i.e. when building the wing loading- thrust loading diagram), we should keep in mind that:

1. **The aspect ratio has influence on the climb rate performance of an aircraft**

2. The aspect ratio has influence on the landing performance of an aircraft
3. The engine power has influence on the landing performance of the aircraft
4. The maximum lift coefficient of the aircraft has no influence on the wing loading
5. The TOP parameter needs to be computed for the top climb gradient estimation

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There are several factors and design choices that directly influence the drag performance of an aircraft. Which of the following would help lowering drag?

1. Lower the Oswald factor
2. Decrease the ratio S/Swet (where S is the reference lifting surface area and Swet is the wetted surface of the aircraft)
3. Increase the cruise lift coefficient (without affecting the lifting surface area)
4. **Lower the equivalent skin friction coefficient**
5. Lower the wing aspect ratio to get a shorter wing

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What is the main advantage of an elliptical lift distribution?

1. Ease of manufacturing
2. Minimizing the wing bending loads
3. Minimize the wing loading
4. Facilitate engine integration
5. **None of the first 4 statements**
6. All of the first 4 statements

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Some of the statements below are wrong:

1. **There is generally a good (almost linear) correlation between aircraft payload weight and range**
2. There is generally a good (almost linear) correlation between the aircraft empty weight and take off weight
3. When performing a regression analysis of statistical data, values of R squared very close to one indicate low scatter values
4. **For a given class of aircraft, the ratio of empty weight and maximum take off weight strongly depends on the range**
5. **The first 4 statements are all wrong**
6. **The first 4 statements are all correct**

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Which of the following options describes the function of a ram air turbine?

1. Provides additional thrust in case of engine failure
2. Converts chemical energy into electrical energy in case of engine failure
3. **Generates energy from the airstream in case of an emergency**
4. Is used during emergencies to accurately measure the airspeed
5. None of the above

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Which of the following statements is true?

1. The drag strut carries lateral loads on the landing gear
2. The tire absorbs all the impact energy during touchdown
3. The shock absorber absorbs all the impact energy during touchdown
4. The side brace carries the longitudinal loads on the landing gear
5. **The braking forces are carried by the drag strut on the landing gear**

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