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COURSE NAME:
(Principles of Aircraft Design)

Assignment Title:
(Assignment on Aircraft Design)

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Introduction

This course was made up of the following course content; Aircraft design as an optimization problem: objectives and constraints. Typical constraints and objective functions in aircraft design. Formulation of the design problem, Stages of the design process: conceptual, preliminary, detailed. Design decision making along the design process. Airworthiness, Documents (standards) and certification categories.

Also, the following modeling was studied; Mission modeling from take-off to landing. Classical thrust to weight and wing loading space analysis in a computational optimization framework. Parametric geometry modeling and Parameterization principles.

Computer Aided Design in aircraft engineering. Setting up the parametric CAD model of an aircraft, from 2d sketches to 3d whole aircraft models. Value-driven design, cost modeling, systems engineering aspects Basic life cycle cost analysis. A systems-level view of aircraft design. Design rationale capture. The role of design rationale capture in the design process. Documenting and using design rationale.

Multiple choice questions

Structural Considerations

1. What is the load path?

a) Structural elements by virtue of which opposing forces are connected

b) Structural elements by virtue of which similar forces are connected

c) Structural elements by virtue of which opposite moments are linked

d) Lifting path

Answer: A

2. We can minimize the weight of the structural member by _____

a) placing opposite forces near to each other

b) placing opposite forces away from each other

c) placing similar forces near to each other

d) placing only upward forces near to each other

Answer: A

3. Span-loading is defined as _____

a) distribution of weight along span as lift distribution

b) thrust loading

c) wing loading

d) inverse of power loading

Answer: A

4. To reduce weight of the structural member we can _____

a) provide shortest and straightest possible load paths

b) provide only straightest possible load paths

c) provide only shortest possible load paths

d) provide shortest and highly curved possible load paths

Answer: A

5. Longerons are used to oppose _____

a) bending

b) expansion only

c) contraction only

d) drag

Answer: A

6. To decrease the weight of a typical commercial fuselage, stringers should be _____

a) straight and uninterrupted

b) straight and curved

c) interrupted at every point

d) only straight

Answer: A

7. Fuselage bending loads are carried by _____

a) keelson

b) tail

c) nelson

d) ribs

Answer: A

8. If possible, we should avoid using any structural cutout.

a) True

b) False

Answer: A

Wing Geometry

1. For high aspect ratio strength of the wing tip vortex is low.

a) True

b) False

Answer: A

2. If aspect ratio of wing is 8 and S=0.1m2 then, what will be the span of wing?

a) 0.89cm

b) 0.89m

c) 0.89

d) 0.89inch

Answer: B

3. Let's consider an aircraft has statistically determined aspect ratio of 8.1. Aircraft has canard which gives contribution of 10% for total lift. Determine the aspect ratio of wing.

a) 9

b) 0.9

c) 10

d) 8.1

Answer: A

4. An aircraft with elliptic wing planform has parasite drag coefficient as 0.6. Lift coefficient of wing is 0.25 and aspect ratio is 7.5. If induced drag co-efficient is 0.0235 then, find total drag coefficient for the wing.

a) 0.0235

b) 0.5235

c) 0.6

d) 0.06235

Answer: D

5. An aircraft with elliptic wing planform has parasite drag coefficient as 0.9. Lift coefficient of wing is 1.8 and aspect ratio is 8.5. Find total drag coefficient for the wing.

a) 1.34

b) 0.9

c) 0.121

d) 1.021

Answer: D

6. Wing sweep is used to ____

a) decrease critical mach number

b) increase critical mach number

c) increase lofting

d) increase drafting

Answer: B

7. Canard pusher aircraft uses wing sweep to change location of aerodynamic centre.

a) True

b) False

Answer: A

8. The ratio of tip and root chord is called ____

a) sweep

b) taper ratio

c) aspect ratio

d) slope

Answer: B

9. If root chord is 2m and tip chord is 0.9m then, find taper ratio.

a) 0.45

b) 0.55

c) 0.65

d) 0.25

Answer: A

Configuration Layout – Wing/Tail Layout

1. As a designer, our task is to design wing layout such that the location of MAC from root chord or centre line is at 8ft. Find the appropriate value of the wingspan if wing is rectangular.

a) 32m

b) 50ft

c) 28m

d) 32ft

Answer: D

2. A fighter jet is flying with wing span of 90ft. If mean aerodynamic chord MAC is at 30ft from tip chord then, to design such wing which type of planform should I use?

a) Triangle

b) Rectangular

c) Square

d) Delta

Answer: D

3. An unstable A/C configuration is a typical wing-aft tail body. IF MAC is 4m then, what would be the approximated location of the CG?

a) 6m

b) 5m

c) 2m

d) 7m

Answer: C

4. As a designer, our job is to design a wing which has root chord Cr as 1m. What should be the approximate radius of fillet?

a) 2m

b) 1m

c) 0.1m

d) 2.1m

Answer: C

5. Which of the following is correct?

a) We can generate flat wrap surface by using linear interpolation method

b) Flat surfaces can only be generated by using linear interpolation

c) Linear interpolation will never give flat surface

d) Linear interpolation is only used for flat wrap surfaces

Answer: A

6. Determine the corrections or otherwise of the following assertion [A] and reason [R]:

Assertion [A]: To generate new airfoil, we use spanwise line instead of chord line in flat wrap interpolation technique.

Reason[R]: Chordwise line will generate flat structure from curves having different values of tangent angle.

a) Both [A] and [R] are true and [R] is the correct reason for [A]

b) Both [A] and [R] are true but [R] is not the correct reason for [A]

c) Both [A] and [R] are false

d) [A] is true but [R] is false

Answer: D

7. At maximum thickness point, fillet is in _____

a) purely vertical plane

b) purely in hp

c) plane at an angle of less than 20° always

d) plane at 45° always

Answer: A

8. Fillet radius is typically more at rear of the aircraft.

a) True

b) False

Answer: A

Radar Detectability

1. RADAR stands for _____

a) radio detection and ranging

b) radio defense and rigging

c) radio determination and ranging

d) radio detection and rigging

Answer: A

2. Radar detection is one of the crucial consideration for military aircraft.

a) True

b) False

Answer: A

3. Typical radar system consists of _____

a) Only Rx

b) Only TX

c) TX and Rx

d) Does not require TX or Rx

Answer: C

4. A typical radar is located at 4 meter distance from an object. If radar transmits signal from that position then, signal strength S will be _____

a) proportional to 4

b) proportional to (1/46)

c) proportional to (1/44)

d) proportional to 1/4

Answer: C

5. RCS stands for _____

a) radar cone shape

b) radar cross section

c) radio conic shape

d) radio cruise and stall

Answer: B

6. RCS is the measure of _____

a) the amount of EM energy is being returned by an object

b) how much weight is required

c) lift generated

d) radio cruise and stall properties

Answer: A

7. RCS can be altered by _____

a) altering the drag force

b) altering the look angle

c) altering the ram cruise and stall

d) altering the tail moment arm only

Answer: B

8. Comment on radar detectability if RCS is higher.

a) Higher detectability

b) Lower detectability

c) Same detectability

d) Detectability is not dependent on rcs

Answer: A

9. Which of the following will not affect the radar detectability of an aircraft?

a) Drag magnitude

b) Look angle

c) Flat surface

d) Stealth properties

Answer: A

10. RCS of flat surface can be reduced by _____

a) provide more rcs to flat side

b) increasing flat side length

c) using twice length of the flat side

d) providing some slope to flat surface

Answer: D

Infrared Detectability

1. An aircraft does not emit any IR radiation.

a) True

b) False

Answer: B

2. In general, an IR detector will respond to?

a) RCS

b) Rotational fluid

c) Rotational force

d) Irradiance

Answer: D

3. Calculate the irradiance E in W/cm2 if, radiant intensity I is 10 W/sr and range R is 10cm.

a) 10

b) 0.001

c) 0.45

d) 0.1

Answer: D

4. What is an IR signature of an aircraft?

a) Total of detectable emissions and reflections

b) Sum of some emissions only

c) Only reflections

d) Only refraction

Answer: A

5. Which of the following is primarily responsible for an IR signature?

a) Fuel tank

b) Passenger

c) Engine exhaust

d) Cabin crew

Answer: C

Visual Detectability

1. Visual detection is based on?

a) Only color

b) Only size

c) Only weight

d) A/C size, color, etc

Answer: D

2. Visual detection is one of the important parameters for an aircraft.

a) True

b) False

Answer: A

3. Which of the following is correct?

a) Lift is always the same as weight

b) Typically, in simulated combat we can detect large aircraft quickly than the smaller aircraft

c) We cannot detect large aircraft at all

d) We can always find small aircraft

Answer: B

4. In order to reduce background contrast, we can provide _____

a) always use red and black pattern

b) red color pattern only

c) always use black color

d) camouflage pattern

Answer: D

5. For ground background, camouflage paint scheme consists _____

a) yellow and red only

b) mottled white

c) black and red

d) mottled grey green

Answer: D

Aural Signature

1. Noise produced by an aircraft is called _____

a) aural signature

b) aurora beam

c) signal beam

d) i beam

Answer: A

2. Primary cause of aircraft noise is _____

a) engine exhaust

b) lift

c) fuselage

d) cabin

Answer: A

3. Small diameter and high velocity jet will produce _____

a) more noise

b) less noise

c) less aural signature

d) independent of diameter and velocity

Answer: A

4. Arrange in the correct order of noise produced by engine type.

a) Turbojet > turbofan > reciprocating engine

b) Turbojet < turbofan < reciprocating engine

c) Turbojet > turbofan = reciprocating engine

d) Turbojet > turbofan < reciprocating engine

Answer: A

5. To reduce piston exhaust noise _____

a) we can use more mufflers

b) mufflers can be used only

c) reduce lift always

d) increase jet speed always

Answer: A

Vulnerability Considerations

1. Vulnerability of an aircraft is ability of the aircraft _____

a) to sustain damage, continue flying and return to base

b) to get damaged and failed

c) to the radar detection

d) to an IR detection

Answer: A

2. _____ is key parameter for vulnerability.

a) IR

b) RCS

c) Vulnerable area

d) Visual area

Answer: C

3. Vulnerable area will be same for each and every aircraft.

a) True

b) False

Answer: A

4. FMEA stands for?

a) Failure mass and effective analogy

b) Failure mass and effect analysis

c) Failure modes and effect analysis

d) Failure modes and effect analogy

Answer: C

5. FMEA will consider _____

a) rcs

b) lift

c) weight by an aircraft

d) which battle damage can affect individual aircraft components?

Answer: D

Crashworthiness Considerations

1. Positioning of the propeller should be such that _____

a) the blades will strike the engine

b) blade should fly off during flight

c) it is always near to cabin

d) blade will not strike anyone if they fly off

Answer: D

2. Typically, in a passenger aircraft fuel is not located in the fuselage.

a) True

b) False

Answer: A

3. What do you mean by crashworthiness?

a) Special aerodynamic lift improvement

b) Capability of an aircraft to stay in cruise

c) Vulnerability to radar detection

d) Capability of structure to protect against impacts and crash loads

Answer: D

4. For large passenger aircraft, floor should be supported by braces at lower part of the fuselage.

a) True

b) False

Answer: B

5. Location of landing gear should be such that _____

a) they must rip open fuel tank during crash

b) they would rip open fuel tanks

c) they wouldn't rip open fuel tanks at the time of crash

d) with less crashworthiness

Answer: C

6. Which of the following is correct?

a) We should avoid placing heavy items behind or above people

b) Lift is always same as weight

c) Drag is always same as thrust

d) Heavy items can be placed as we want

Answer: A

Producibility Considerations

1. Aircraft production cost is related to _____

a) weight only

b) weight, size, material, etc

c) size only

d) material only

Answer: B

2. Aircraft production cost can be reduced by using _____

a) flat wrap surfaces

b) non-flat surface

c) more forging processes

d) welding only on non-flat surfaces

Answer: A

3. _____ are one of the most expensive type of structure in general.

a) Non-lifting only

b) Lifting only

c) Forging

d) Only high speed bodies

Answer: C

4. To simplify routing requirements we can provide _____

a) increasing cruise weight

b) structural break

c) reducing lift at cruise

d) routing tunnels

Answer: D

5. Careful placement of the internal components can reduce routing cost.

a) True

b) False

Answer: A

Maintainability Considerations

1. What is Maintainability?

a) RCS detection

b) The ease with which the aircraft can sustain damage

c) Vulnerability

d) The ease with which the aircraft can be fixed

Answer: D

2. R&M are measured in?

a) Vulnerable area

b) Maintenance man-hours per flight hour

c) RCS of system

d) Maintenance and research

Answer: B

3. What is the Major Key parameter of maintainability?

a) RCS

b) Survival

c) Accessibility

d) Vulnerability

Answer: C

4. Which of the following is correct?

a) Accessible parts cannot be considered maintainability

b) Avionics systems should be not accessible at all

c) Large doors should be provided for the avionics system

d) Lift is axlways same as weight during ground maintenance

Answer: C

5. Best access should be given to components which require often maintenance.

a) True

b) False

Answer: A

Crew Station

1. Crew station design is affected by?

a) Weight effects only

b) Lift only

c) Vision requirements

d) Drag required only

Answer: C

2. Which of the following is correct?

a) Cockpit design is not affected by visual requirements

b) Crew station design is based on lift only

c) Vision requirements will be used to determine location of cockpit

d) Weight will be always same as lift

Answer: C

3. Why some slope is provided at the nose of an aircraft?

a) Only to increase lift

b) To provide obstruction to vision

c) To provide unobstructed runway vision

d) Only to reduce weight

Answer: B

4. Which of the following is incorrect?

a) Cockpit design is affected by visual requirements of pilot

b) Lofting is mathematical model for skin

c) Conceptual design is first phase of the design process

d) Cockpit is always located directly above the wing

Answer: D

5. Over- side vision requirements prevent locating the cockpit directly above wings.

a) True

b) False

Answer: A

Passenger Compartment

1. Passenger cabin is defined by _____

a) aisle only

b) pitch only

c) headroom only

d) pitch, headroom, aisle, etc

Answer: D

2. Pitch is defined as _____

a) Height of seat

b) Distance from the back of one seat to the back of next respective seat

c) Height of seat minus height of next respective seat

d) Length of one seat plus height of seat

Answer: B

3. What do you mean by aisle?

a) Height of seat from floor

b) Passage between two rows

c) Height of seat measured height of next respective seat

d) Length of one seat plus height of seat of second row

Answer: B

4. An aircraft has 6 seats in one row then, find the ideal value of aisle numbers.

a) 3

b) 5

c) 2

d) 9

Answer: C

Payload – Weapons Carriage

1. Typically, Which weapons are utilized for missions?

a) Missile, gun, bombs, etc

b) High lift device

c) Vortex generator

d) Bombs only

Answer: A

2. Typically, weapons are located near to _____

a) CG of aircraft

b) Aft CG

c) Fore CG

d) Always at tail section

Answer: A

3. Which of the following is correct?

a) Missile can be launched in two ways typically

b) Missile are always free fall

c) Bombs are always guided

d) All Missile and bombs adopt similar launching mechanism

Answer: A

4. Which of the following is a type of weapon carriage?

a) Conformal

b) Uni Conformal

c) Omni external

d) Tail dragger

Answer: A

5. All the fighter aircrafts incorporate only external weapon carriage.

a) True

b) False

Answer: A

Conclusion

This course covered Aircraft design principles blending both synthesis and analysis. The iterative nature of the design process. Applied aerodynamics. Elements of aircraft performance calculation and optimization. Design of aircraft including payload, crew and avionics provisions, propulsion selection and sizing, aerodynamic configuration optimization, mass properties, stability and control characteristics, and vehicle subsystems.

Bibliography

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