



B.E DEGREE EXAMINATIONS:MAY 2017

(Regulation 2015)

Fourth Semester

AERONAUTICAL ENGINEERING

U15AET404: Aircraft Propulsion

COURSE OUTCOMES

- CO1:** Analyze thermodynamics of an aircraft jet engine and calculate the performance measures, such as thrust and specific fuel consumption in terms of design requirement.
- CO2:** Estimate the best possible engine performance as a function of principal design parameters, such as maximum engine temperature, pressure ratio, and flight speed.
- CO3:** Analyze the internal mechanisms of gas turbine engine components and understand the factors that limit the practical performance of inlets, combustion chambers, and nozzles.
- CO4:** Evaluate the operating characteristics of compressors and turbines in terms of given blade shapes, angles, and direction of rotation.
- CO5:** Design a gas turbine engine using the understanding of the relationship between components, at least at the level of selecting the number of spools and stages.

Time: Three Hours

Maximum Marks: 100

Answer all the Questions:-

PART A (10 x 1 = 10 Marks)

1. Match the appropriate engine with the corresponding aircraft for most efficient performance CO1 [K₂] of the engine

List I		List II	
A. Low speed transport aircraft		i. Scramjet	
B. High subsonic civilian aircraft		ii. Turboprop	
C. Supersonic fighter aircraft		iii. Turbojet	
D. Hypersonic aircraft		iv. Turbofan	

- | | A | B | C | D |
|----|-----|----|-----|----|
| a) | iii | ii | iv | i |
| b) | ii | iv | iii | i |
| c) | ii | i | iii | iv |
| d) | iii | ii | i | iv |

2. Which one of the following aero engines has the highest propulsive efficiency? COL [K_L]
- a) Turbojet with after burner b) Turbojet without after burner
 c) Turbofan engine d) Ramjet engine
3. For a given fuel flow rate and thermal efficiency, the take-off thrust for a gas turbine engine burning aviation turbine fuel (considering fuel-air ratio $f \ll 1$) is COL [K_L]
- a) Directly proportional to exhaust velocity b) Inversely proportional to exhaust velocity
 c) Independent of exhaust velocity d) Directly proportional to the square of the exhaust velocity
4. The ratio of flight speed to the exhaust velocity for maximum propulsion efficiency is COL [K_L]
- a) 0.0 b) 0.5
 c) 1.0 d) 2.0
5. For an ideal cycle analysis which of the following assumptions are correct CO2 [K₁]
1. Combustion takes place at constant volume.
 2. Working fluid is air which has constant specific heats.
 3. Nozzle expands the gas to the ambient pressure.
 4. Compression and expansion process are irreversible.
- a) 1,4 b) 2,3
 c) 1,2 d) 2,4
6. The total pressure at a point is defined as the pressure when the flow is brought to rest CO1 [K₁]
- a) Adiabatically b) Isentropically
 c) Isothermally d) Isobarically
7. For a fifty percent reaction axial compressor stage, following statements are given CO3 [K₂]
- I. Velocity triangles at the entry and exit of the rotor are symmetrical
 II. The whirls or swirl component of absolute velocity at the entry of rotor and entry of stator are same.
- a) Both I and II are correct statements b) I is correct but II is incorrect
 c) I is incorrect but II is correct d) Both I and II are incorrect
8. A turbo fan engine has a bypass ratio of 5 and a total mass flow rate is 120kg/s. The mass flow rate through bypass duct is CO1 [K₂]
- a) 20 kg/s b) 100 kg/s
 c) 120 kg/s d) 600 kg/s

9. Arrange the following jet engine components operated with after burner in a sequence CO2 [K₁]
 1. Compressor 2. Combustion chamber 3. Inlet. 4. Nozzle 5. Afterburner 6. turbine
- a) 2-3-1-4-6-5 b) 4-3-2-1-6-5
 c) 3-1-2-6-5-4 d) 1-2-3-4-5-6
10. A gas turbine engine is mounted on an aircraft which can attain a maximum altitude of 11 km CO3 [K₂]
 from sea level. The combustor volume of this engine is decided based on conditions at
- a) Sea level b) 8 km altitude
 c) 5.5 km altitude d) 11 km altitude

PART B (10 x 2 = 20 Marks)

(Answer not more than 40 words)

11. Define Froude efficiency. CO1 [K₂]
 12. Define Bypass ratio. CO1 [K₂]
 13. What is “buzz” in supersonic inlets? CO2 [K₂]
 14. What is meant by ram recovery point? CO2 [K₂]
 15. Define Combustion intensity. CO3 [K₂]
 16. Define slip factor and degree of reaction for an axial flow compressor. CO3 [K₂]
 17. Differentiate between impulse stage and reaction stage turbines. CO4 [K₂]
 18. What is the function of an after burner? CO2 [K₂]
 19. What are the various losses in a nozzle? CO5 [K₂]
 20. What do you mean by thrust reversal? CO2 [K₂]

Answer any FIVE Questions:-

PART C (5 x 14 = 70 Marks)

(Answer not more than 300 words)

Q.No. 21 is Compulsory

21. Compare external deceleration and internal deceleration and hence derive an expression showing the relation between minimum area ratio and deceleration ratio. CO2 [K₃]
22. i) What is meant by thrust? Derive the thrust equation for general propulsion system. (7) CO1 [K₃]
(7) CO1 [K₂]
 ii) Describe the working of a turbofan engine with illustrative sketches and also draw T-s diagram for ideal and real cycles.

23. i) Explain the various factors that affect the combustion chamber performance (7) CO3 [K₂]
 ii) Write down the methods of flame stabilization and explain with neat sketches (7)
24. A centrifugal compressor takes in gas at 0°C and 0.7bar and delivers at 1.05 bar. CO3 [K₃]
 The efficiency of the process compared with adiabatic compression is 83%. The specific heat of the gas at constant pressure and constant volume are 1.005 and 0.717 KJ/KgK respectively. Calculate the final temperature of the gas and workdone per unit mass of gas. If the gas were further compressed by passing through a second compressor having the same pressure ratio and efficiency with no cooling between the compressors, what would be the overall efficiency of the complete process?
25. Discuss briefly the following: (7+7) CO4 [K₃]
 i) Methods of turbine blade cooling ii) Matching procedure for turbine and compressor.
26. Discuss the back pressure control in convergent nozzles and also explain over expansion, optimal expansion and under expansion with neat sketches. CO5 [K₂]
27. An aircraft using a simple turbojet engine, flies at Mach 0.8 where the ambient temperature and pressure are 223.3 K and 0.265 bar, respectively. CO1 [K₃]
 The compressor pressure ratio is 8.0 and the turbine inlet temperature is 1200 K. The isentropic efficiencies of: compressor =0.87, turbine =0.90, intake=0.93, nozzle =0.95, mechanical =0.99, combustor =0.98. The pressure loss in the combustor = 4% of compressor delivery pressure. Determine the thrust and SFC.
