UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2012/2013

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DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF EIGHT (8) PAGES

INSTRUCTION : ANSWER FOUR (4) QUESTIONS ONLY

Q1 (a) Describe the following piston engine configurations:

- Inline engine
- V-type engine
- Radial engine
- Horizontally opposed engine

(8 marks)

(b) A Cessna aircraft is equipped with two in line engine is flying at 1000 m with ambient conditions of 281.65 K and 89.9 kPa respectively. The engine which is a 4 stroke six piston engine rotates at 3500 rpm. The clearance volume is 5% of its swept volume. The ratio of air to fuel (by mass) is 16:1 and the fuel Low Heating Value is 44,500 kJ/kg. The mechanical η_m and propulsive η_P efficiencies are 0.8 and 0.75 respectively. If the swept volume of each cylinder is 9.42 x 10^{-4} m^3 and the dimensions of the bore and stroke are similar, calculate:

(i) The total brake shaft power, $\dot{W}_B$
(ii) The brake specific fuel consumption, $BSFC$ of each engine if the fuel flow is 0.01 kg/s
(iii) The thermal efficiency, η_{th} of each engine

Use γ = 1.4 and $C_v = 0.718$ kJ/kg for air.

(17 marks)

Q2 (a) Compare between a turbojet, turbofan, turboprop and turboshaft in terms of its purpose, output and characteristics

(8 marks)

(b) Two single spool turbojet engine fitted with an afterburner as schematically shown in Figure Q2(b) is used to power the Lockheed. At 6000 m, when the afterburner is activated, the speed of the Lockheed reaches Mach 0.7. The ambient conditions at 6000 m with 21.1 ISA deviation are 270.25 K and 47.18 kPa respectively. The compressor pressure ratio and the turbine entry temperature is 23 and 1450 K. The inlet mass flow is 55 kg/s and the fuel Low Heating Value is 42,000 kJ/kg. If the gas temperature exiting the afterburner is 1815 K, using an ideal cycle approach, calculate for each engine:

(i) The engine thrust, F_N
(ii) The thrust specific fuel consumption, $TSFC$
(iii) The propulsive efficiency, η_P

Sketch the Ts diagram and use $\gamma = 1.4$ and $C_p = 1.005$ kJ/kg for air.

From the values obtained, what sort of understanding can we achieve with regards to its engine performance?

(17 marks)

Q3 (a) Describe briefly the main function of the following components:

(i) Intake
(ii) Compressor
(iii) Burner
(iv) Turbine
(v) Nozzle

(10 marks)

(b) A two spool turbofan with unmixed nozzle is used to power a commercial airplane. The half diagram of the engine arrangement is given in Figure Q3(b). The low pressure spool connects the fan to the low pressure turbine while the high pressure spool connects the compressor to the high pressure turbine. The plane is flying at 8,000 m with Mach number 0.6. At this altitude, the ambient temperature and pressure are 251.15 K and 35.6 kPa respectively. The fan and the compressor pressure ratios are 1.5 and 10 respectively. Also, the bypass ratio is 5 and the turbine entry temperature is 1700 K. If the inlet mass flow is 85 kg/s and the fuel Low Heating Value is 43,000 kJ/kg, using an ideal cycle approach, calculate:

(i) The overall pressure ratio of the compression system, $PR_{Overall}$
(ii) The engine thrust, F_N
(iii) The thrust specific fuel consumption, $TSFC$

Sketch the Ts diagram and take $\gamma = 1.4$ and $C_p = 1.005$ kJ/kg.

(15 marks)

Q4 (a) Describe briefly the following thrust and drag components:

(i) Pressure thrust
(ii) Momentum thrust
(iii) Momentum drag
(iv) Gross thrust
(v) Net thrust

(5 marks)

(b) A turbojet is powering an aircraft flying at 7000 m with a speed of 600 km/h. The ambient conditions at 7000 m are 252.65 K and 41 kPa respectively. The inlet and outlet area of the engine are 0.22 and 0.248 m^2 respectively. The FAR is 0.016 while the nozzle exit pressure and velocity are 200kPa and 600 m/s respectively. Calculate:

(i) The pressure thrust
(ii) The momentum drag
(iii) The momentum thrust
(iv) The gross thrust
(v) The net thrust

(10 marks)

(c) Figure Q4(c) shows the results of multiple design point calculation of a turbojet with various turbine entry temperature (TET) and pressure ratio (PR). Discuss the results in terms of its effects of thrust specific fuel consumption (TSFC) and thrust (Fn). Discuss also how the decision of a design point selected in the figure can affect the design and the performance of the turbojet.

(10 marks)

Q5 (a) Lists the three assumptions that are not made when real cycle analysis is carried out.

(3 marks)

(b) Compare the effect of chocked and un-choked nozzle on the thrust generated.

(2 marks)