CEE 5614: Analysis of Air Transportation Systems **Fall 2020**

Quiz 1 : Open Notes

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Problem 1

Use the very light jet aircraft file provided in class http://128.173.204.63/courses/cee5614/cee5614_pub/eclipse500New_class.m) to answer the following questions. Assume ISA atmospheric conditions in your calculations.

a) Based on the data provided, estimate the Top of Climb Point (TOC) altitude if the air taxi pilot wants to cruise at an initial altitude that provides a minimum climb rate of 500 ft/minute. The aircraft departs an airport located 2,320 feet above mean sea level conditions and the departure mass is 2,700 kilograms. State the selected TOC altitude.

a) Run the unrestricted climb profile Matlab code with the correct initial conditions:

mass = 2700 kilograms

h_airport = 707 meters (2320 feet)

b) Find (through interpolation) the rate of climb (500 ft/min) 152 m/minute to get ~9400 meters. Depending upon the direction of flight, the possible flight levels are FL 300 and FL 310.

b) During the climb, Air Traffic control holds the very light jet at FL 170 for 2 minutes due to traffic. Estimate the fuel burn during the two-minute hold if the pilot selects 230 knots Indicated Airspeed.

At 230 knots, Drag at FL170 is 2060 Newtons. The fuel burn is 0.046 kg/s. In 2 minutes, the aircraft burns 5.2 kilograms.

c) Estimate the fuel used to reach the TOC altitude selected in part (a).

Assuming FL300 is used in the calculation, the total fuel is 87 kilograms.

d) Find the Indicated Airspeed for an optimal (i.e., highest) rate of climb as the aircraft climbs through 5,000 meters. State your method and show sample calculations to find such speed.

Use an iterative method to find the optimal climb speed. I used a speed vector from 150 to 250 knots indicated airspeed to estimate the rate of climb for each speed (at one knot increments). The optimal climb speed is 185 knots (see plot).

```
global A e S neng tsfc macht Cdoct
global mass thrust_table mach_table lapse_rate_factor
global g

% Define a speed vector (IAS)

speed = 150:1:250;      % indicated airspeed knots
altitude = 5000;        % meters
eclipse500New_class     % loads the file
mass = 2650;            % kilograms
phi = 0;
g =9.81;

% Calculate the Mach number for each speed

[mach,speedSound,rho,temp] = isam(altitude,speed);
trueAirspeed = mach * speedSound;                    % m/s

% Calculate drag

[drag,LD,lift_coefficient,drag_coefficient]=drag_calculator(mach,rho,speedSound,mass,macht,Cdoct,phi);

% Calculate thrust

[thrust] = thrust_calculationNoLoss(thrust_table,mach_table,lapse_rate_factor,mach,rho);

% Calculate the rate of climb

ROC = (thrust - drag) .* trueAirspeed ./ (mass * g);

% Plot the indicated speed to ROC
```

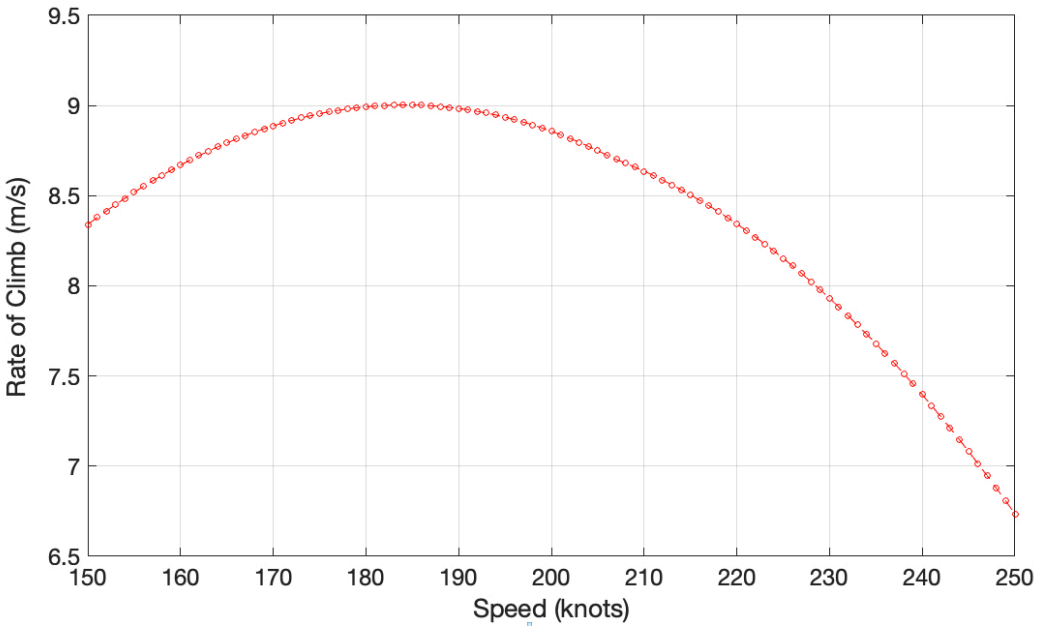

Figure 1. Rate of Climb for Eclipse 500 Very Light Jet Aircraft.

Problem 2

A cargo airline is considering non-stop operations from Salt Lake City (Utah) to Chengdu (China) using Boeing 747-8F aircraft. The aircraft has a MTOW of 987,000 lb. The engine used is the GEnx 2B engine.

a) Is the airline able to operate the route at MTOW? State your calculations to support your answer. Show temperature used and indicate the figures in the Boeing document used.

The design temperature at Salt Lake is 90 deg. F. The design temperature is then ISA + 45 deg. F or ISA + 25 deg. Celsius.

Longest runway available is 12,202 feet.

Impossible to operate at MTGW from SLC. Maximum operating takeoff weight for given conditions is ~870,000 lb.

b) if the answer in part (a) is no, then estimate the maximum weight departing Salt Lake.

DTW for given conditions the maximum operating weight from SLC is ~870,000 lb.

c) Find the runway length departing Salt Lake on a very hot summer day (ISA + 25 deg. C.). What is the flap setting used?

15,100 feet at 940,000 lb. limited by Brake Energy boundary according to the Boeing data.

d) Compare the Payload/Range diagrams for the Boeing 747-8F and the 747-8 (passenger version). Describe some of the differences in performance between the two aircraft. State a possible explanation for the difference in performance (if any).

Substantial difference in the Maximum Zero Fuel Weight (MZFW). Boeing 747-8F has MZFW of 727,000 lbs. The MZFW for the passenger version is 651,000 lbs. The passenger version carries large amount of weight in seats, galleys, and electronics needed for passengers. The cargo version does not require the additional weight and can carry that weight as payload instead.

The Boeing 747-8F carries the maximum payload for 4,250 nm. The passenger version can fly 5,800 nm with the maximum payload (albeit smaller payload than the Boeing 747-8F).

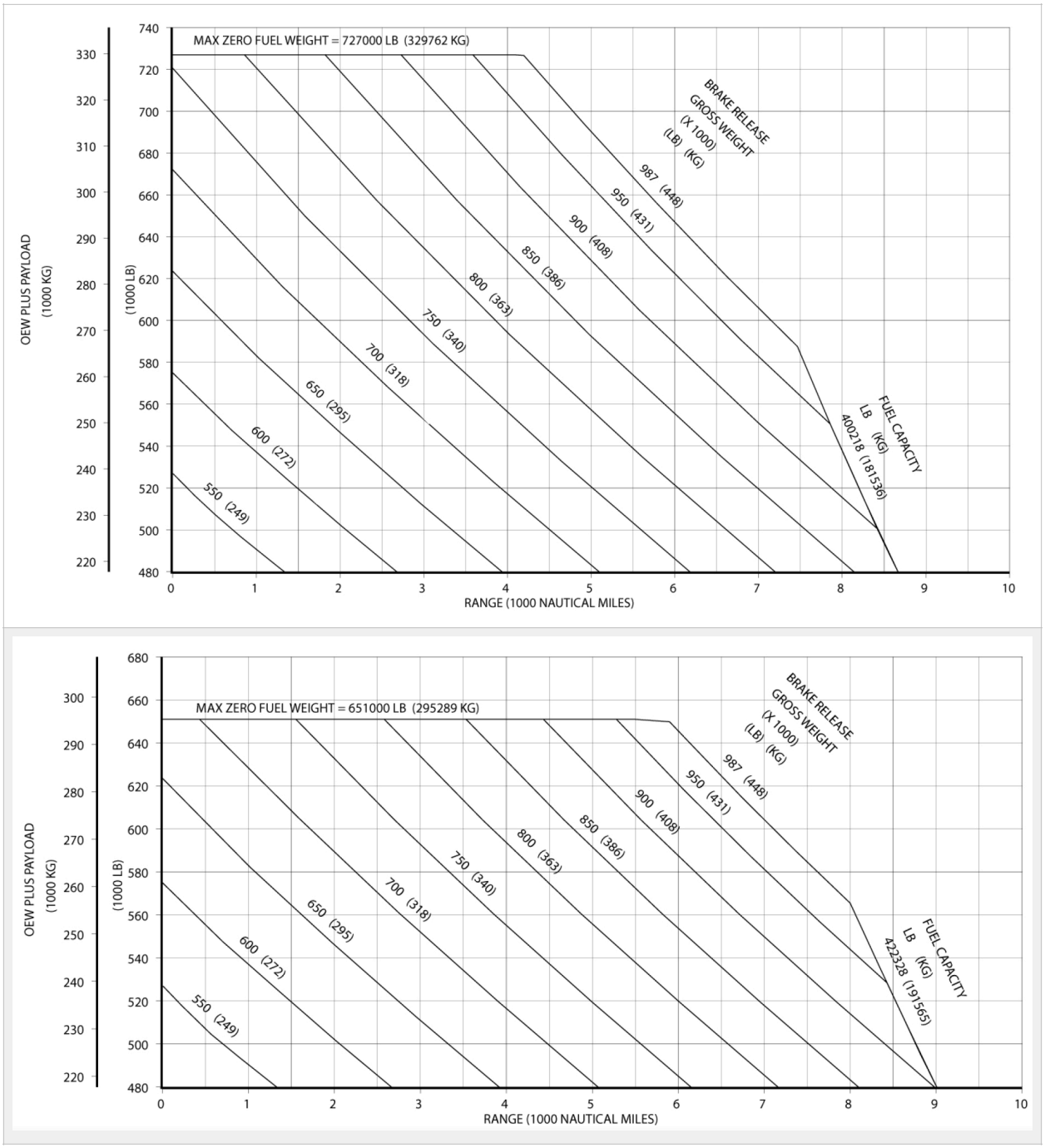

Figure 2. Boeing 747-8 F (Top) and Boeing 747-8I (Bottom).