Assignment 4: Air Transportation Systems Analysis

Solution Instructor: Trani

Problem 1

Use the large, twin-engine transport aircraft to answer this question (http://128.173.204.63/courses/cee5614/cee5614_pub/boeing777_class_2006.m).

a) Estimate the rate of climb after the aircraft departs Chicago O'Hare International Airport (ORD) at a point 150 meters above the airport ground level. Assume the aircraft has takeoff flaps of 10 degrees which adds 0.010 to the draft coefficient. The aircraft departs ORD airport with a mass of 320,000 kilograms. The indicated airspeed at the point of interest is 190 knots.

ORD airport is located at 207 meters above sea level. The initial condition for the aircraft is **then 357 meters above sea level and 190 knots indicated.**

Mach = 0.2922

Density = 1.1837

speedOfSound = 338.91 m/s

Use the unrestricted climb algorithm. The following changes were made to the Boeing 777_class file:

a) Add the drag due to flaps (0.010)

```
% Drag characteristics - CDO function (zero lift drag function)
Cdoct    = [0.017   0.017   0.0175    0.021   0.024   0.034    0.060] + 0.01;
macht    = [0.000   0.750   0.8000    0.850   0.900   0.950    1.000];
```

Change the speed profile to the desired climb profile.

```
Vclimb = [190 190  190 230 250  260  290  290  290  290  290  300 300  300  300];      % knots IAS
Vdescent = [180 200  250 250 270  300  300  300  300  300  300  300 300  300  300];   % knots IAS
altc = [ 0 1000  2000 3000 4000  5000  6000  7000  8000  9000  10000  11000 12000  13000  14000]; % altitude (meters)
```

The script produces several plots and we reuse the numbers. At 190 knots the rate of climb is 1140 meters per minute.

At 190 knots with one engine failed, the rate of climb is 295 meters per minute.

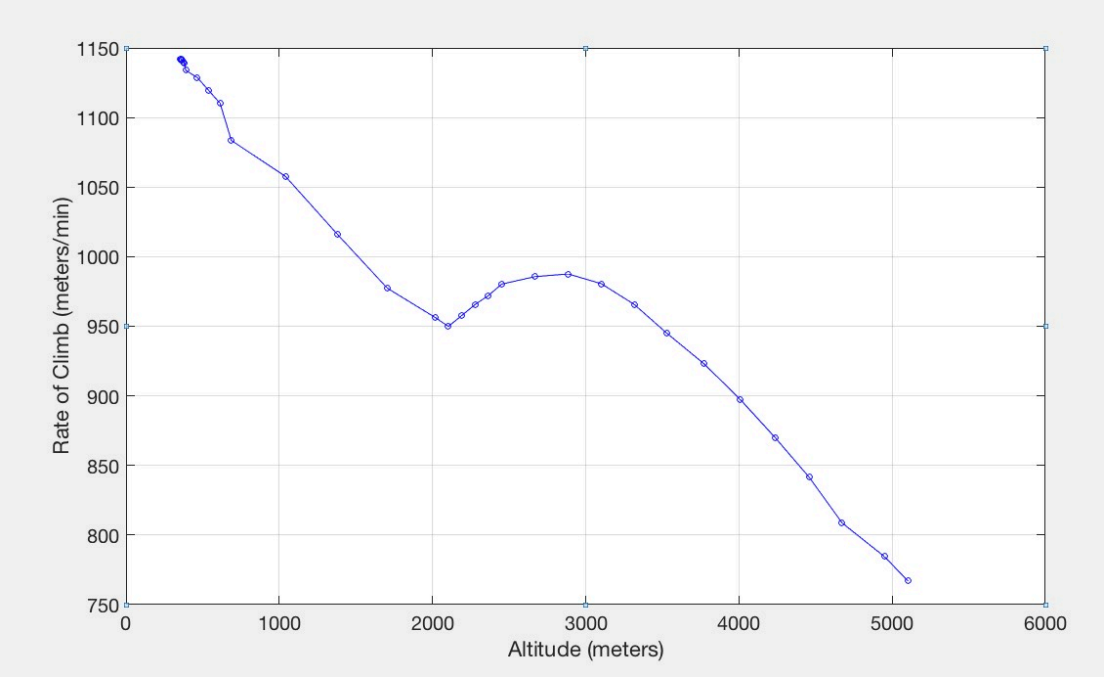


Figure 1. Rate of Climb for Boeing 777-Class Aircraft (All Engines Working).

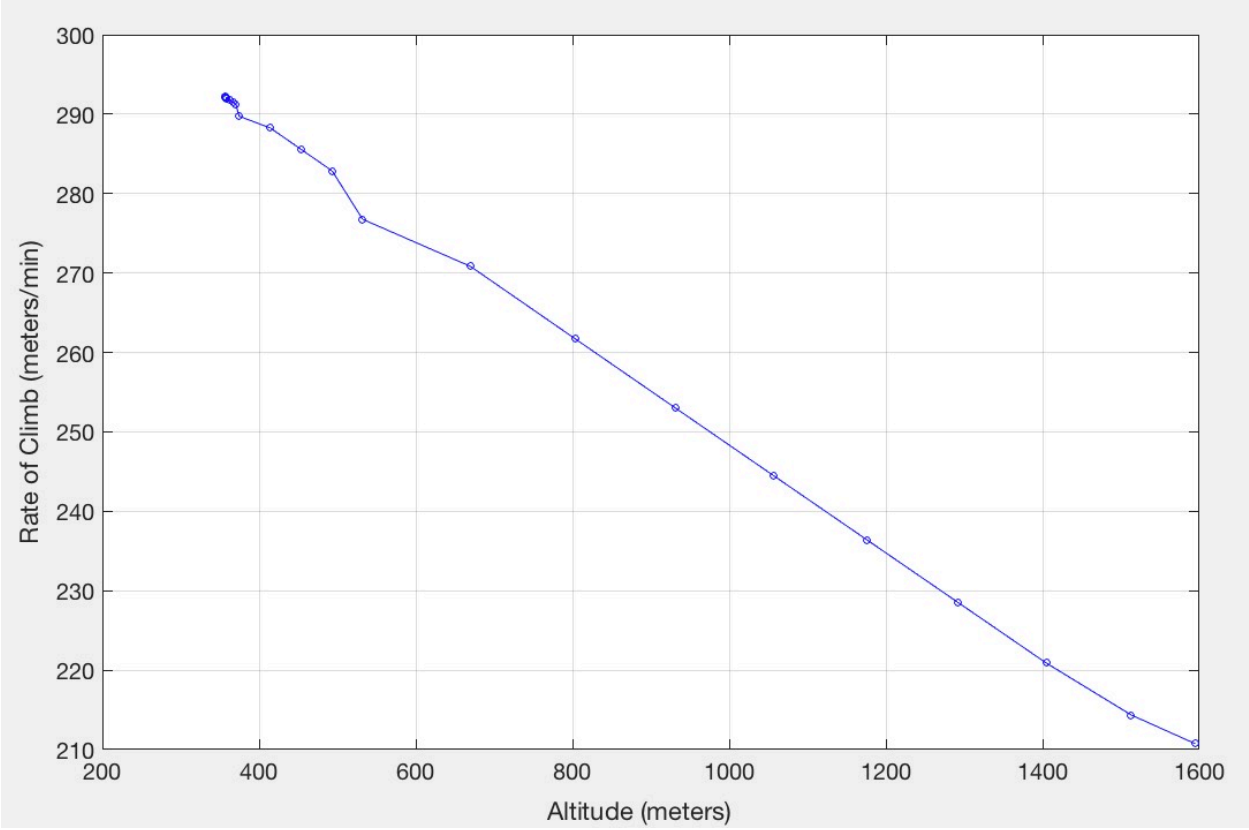


Figure 2. Rate of Climb for Boeing 777-Class Aircraft (One Engine Failed).

b) Will the aircraft be able to clear a 1,200 meter obstacle (above ground level) located 6.3 nm from the point of engine failure? The minimum clearance vertical distance to an obstacle is 300 meters.

True airspeed is 99.04 m/s or 194.2 knots at a point 357 meters above sea level. 11,668 meters flown to reach 6.3 nm from the runway threshold. Assume rate of climb is constant with 293 m/minute (calculated using unrestricted climb analysis) with an engine out. It takes 117.8 seconds to reach the 6.3 nm point. At that point, the aircraft has climbed: 579 meters above the 357 meter departure point. Aircraft is 1899 meters above the obstruction. The obstacle is cleared.

Problem 2

The new generation, twin-engine transport aircraft to answer this question (http://128.173.204.63/courses/cee5614/cee5614_pub/boeing787_class.m).

a) Estimate the value of SAR for the aircraft if the aircraft reaches the TOC point (10,000 meters) at 191,000 kilograms. The aircraft cruises at Mach 0.83.indicated airspeed

At Mach 0.83 and 10,000 meters, the speed of sound is 299.5 m/s. True airspeed is 248.6 m/s.

Drag = 114,680 N

Fuel Burn = TSFC * Drag = (1.53e-4)(114680)

Fuel Burn = 17.54 N/s

SAR = V/ (TFSC * T) = V/ (TFSC * D)

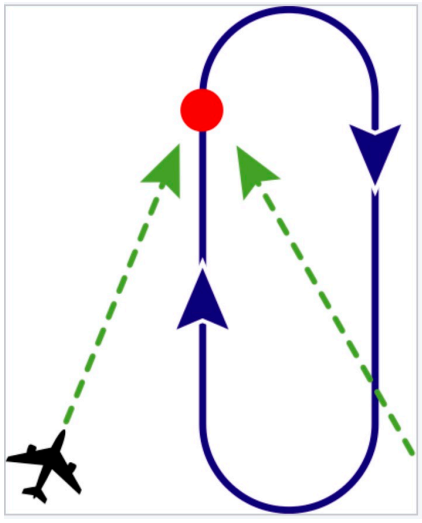
SAR = 248.58 / (1.53e-4 * 114,680)

SAR = 14.16 meters/Newton of fuel

SAR = 0.139 km/kilogram of fuel

SAR = 0.0751 nautical miles/kilogram of fuel

b) Use the Range equation, to estimate the maximum range for the aircraft if the aircraft reaches the TOC point (10,000 meters) at 191,000 kilograms. The aircraft cruises at Mach 0.83. The pilot estimates the aircraft carries 75,000 kilograms of fuel remaining at the TOC point.



At Mach 0.83 and 10,000 meters, the speed of sound is 299.5 m/s. True airspeed is 248.6 m/s.

Drag = 114,680 N

Wi = 191,000 kg

Wf = 116,000 kg

R = V/(TSFC)*(L/D) ln (Wi/Wf)

R = V/(TSFC)*(mg/D) ln (Wi/Wf)

R = (248.6/1.53e-4)*(191000 * 9.81)/114680 * ln (191000/11600)

R = 7.4367e+07 meters

R = 7.4367e+04 kilometers