Question 1 Answers

1) $P = F.V = (0.9)(150{,}000) = F.(65\text{x}0.447)$

Points

$$\boxed{F = 4{,}646\text{ N}}$$

Points	
1 5	— 2 not count 0, 9 — 1 each random
2 9	— 3 for slower — 1 miscale A — 1 random
3 6	— 3 for V1 — 2 for V2 — 1 random — 1 don't count
4 a) 2 b) 3	— anything reasonable — 1 each

2) $F = m\,(V_0 - V_i)$

$$F = \rho.V_0.A(V_0 - V_i)$$
$$V_0^2(A.\rho) - V_0(V_i.A.\rho) - F = 0$$
$$A = \pi(0.06)^2 = 0.01131\;m^2$$
$$V_i = 29.055\;m/s$$
$$V_0^2(11.3) - V_0(328.6) - 4{,}646 = 0$$
$$\frac{328.6 \pm \sqrt{328.6^2 + 4\,.(11.3\text{x}\,4{,}646)}}{2(11.3)} = \frac{328.6 \pm 563.9}{22.6}$$

$$\boxed{V_0 = 39.49\,m/s} \approx 88.3\;mph$$

3) $F \approx V^2 \qquad F_2 = \frac{90^2}{60^2}\,.4{,}646 = 8{,}907\;N$

$\frac{V_2^1}{V_1^2}\,.F_1 = F_2 \qquad P = F.V = 358{,}334W$

@engine: $\frac{1}{0.9}.358{,}334 =$ $\boxed{398{,}148\text{W}}$ = 533Hp

4) A) No; mass flow wasted to keep rider up.

B) – Volume output of pump

— max pressure of pump

—drag force @ boat @ speed

— rider weight

Question 2: Aircraft Aerodynamics (25 points)

A small commercial airplane weighing 20,000 lbs flies at a cruising attitude of 33,000 feet. The ambient air density is 7.9656 X 10 slug/ft^3. The wing surface area is 450 ft^2.

a) Draw a free body diagram of all of the forces acting on the airliner at cruising speed. What is the lift force.

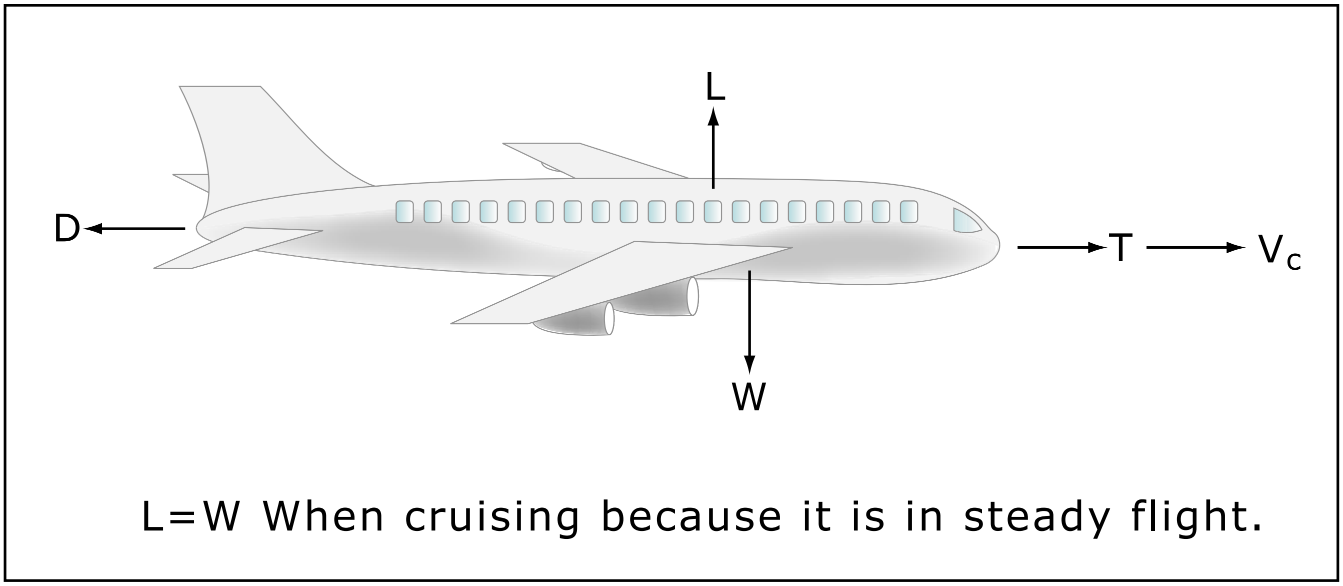

Image by MIT OpenCourseWare.

b) Which of the following would be a reasonable lift/drag ratio? Select one value, then calculate the forward thrust of the airplane.

Select a L/D ratio:

1/200   1/20   1   (20)   200

$\frac{L}{D} = 20 \qquad D = \frac{L}{20} \qquad T = \frac{W}{20}$

$$T = \frac{20{,}000\ lbs}{20} \qquad T = 1000\ lbs$$

c) Given the L/D ratio selected in part b, we would like to determine the stall velocity of the airplane. Assume C_D = 0.015 as the airplane enters stall.

$\frac{L}{D} \propto \frac{C_L}{C_D} \qquad 20.\ C_D = C_L$

$$C_L = 0.30$$

$$C_L = \frac{2W}{\rho_\infty V_\infty^2 . S}$$

$$V_\infty = \sqrt{\frac{2W}{\rho_\infty\ .S.C_L}} = \sqrt{\frac{2(20{,}000\ lbs)}{(7.9656\ X\ 10^{-4} slug/ft^3)(450\ ft^2)(0.3)}}$$

$$V_\infty = 609.9\ ft/s$$

Question 3: Signal Processing (20 points)

The base signal in Figure 1 is modulated using Double-sideband suppressed-carrier transmission (DSB-SC), the result of which is shown in Figure 1. In order to interpret the signal on the receiver end, we perform a Fourier transform of the incoming data, with the output shown in figure 2.

Identify the carrier frequency and the frequency components of the base band signal.

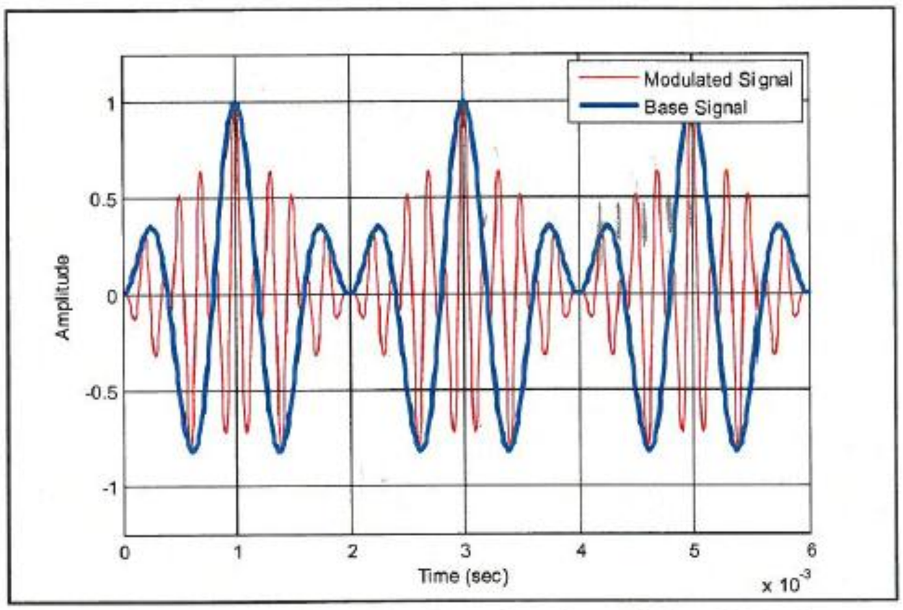

Figure 1: Base Signal and Amplitude Modulated Signal

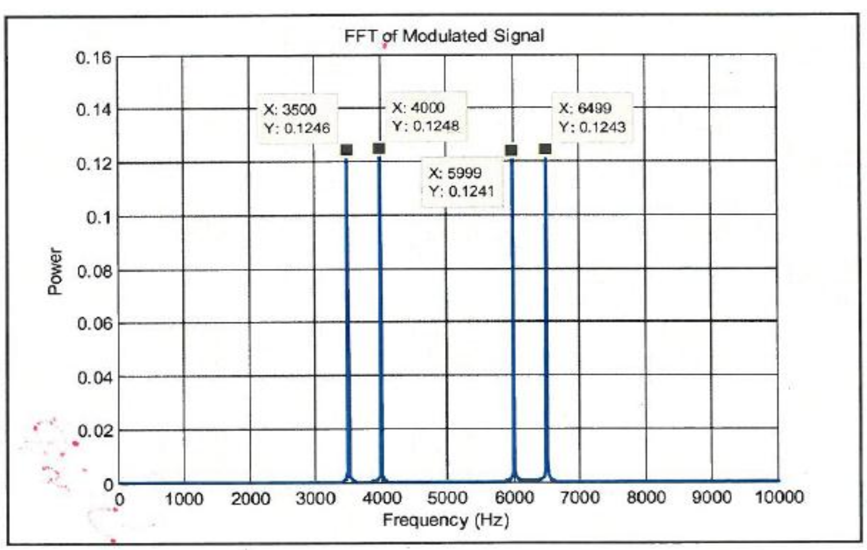

Figure 2: FFT of DSB-SC Signal **(Positive Transform Only)**

Carrier Signal (Hz)

$F_C = 5000Hz$

(According to FFT plot)

Base Band Signal (Hz)

(Use as many frequencies as needed to fully describe the signal)

$F_{B1} =$ 1000 Hz

$F_{B2} =$ 1500 Hz

$F_{B3} =$ -

$F_{B4} =$ -

Question 4 Answers

1)

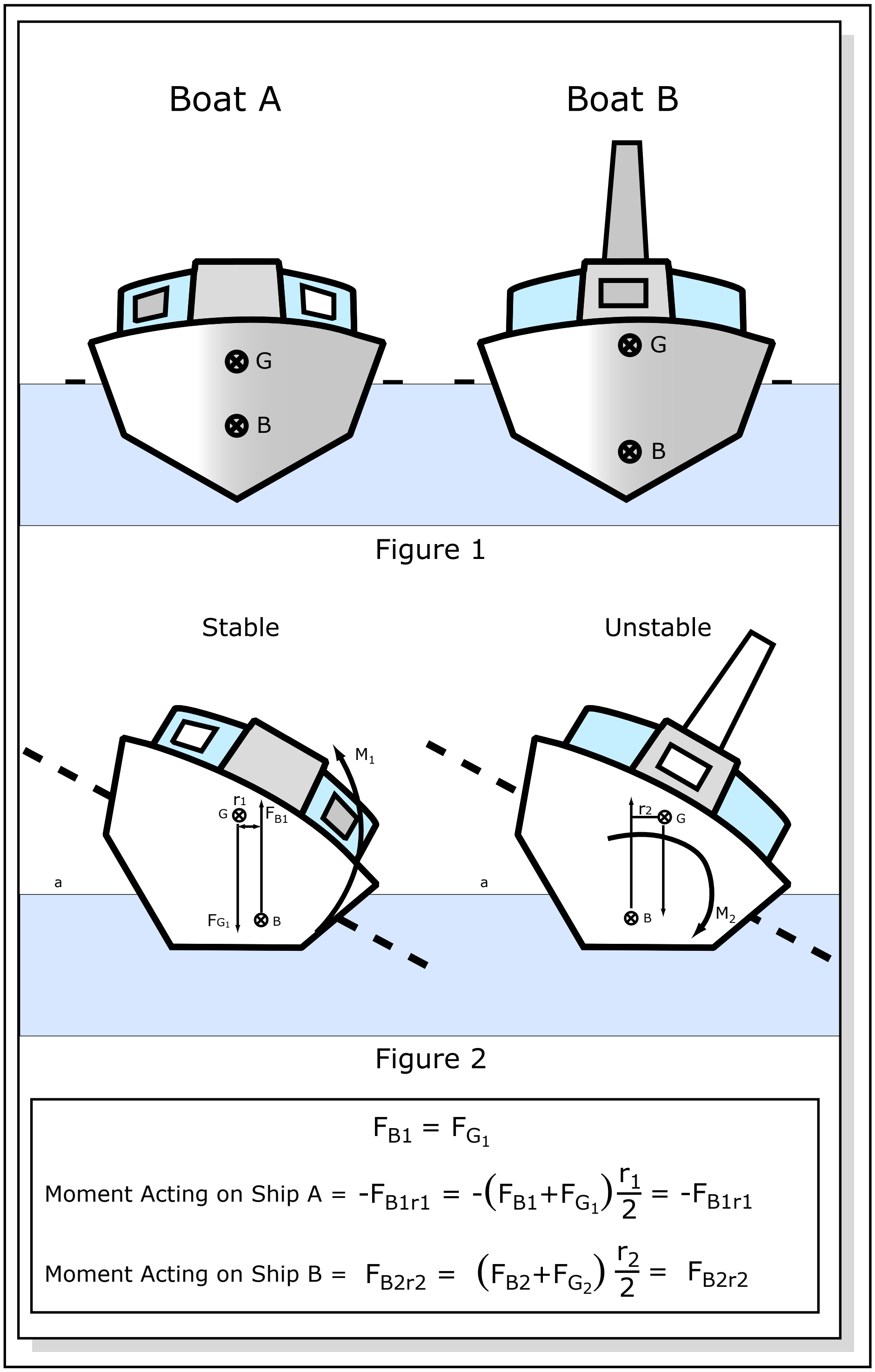

Image by MIT OpenCourseWare.

2) By re-using the heat from the exhaust gases to pre-heat the compressed intake air, reducing the amount of fuel needed to be burned for the heat-addition to the Brayton cycle .
3) Three. More satellites would allow for averaging of the time-stamp signal and greater accuracy due to correction for the satellite reference time drift.
4) Based on the design speed of the aircraft. Turbofans can attain lower engine outlet velocities at higher mass-flow rates, allowing for more efficient propulsion at lower speed.
5) Angle of Attack

16.682 Technology in Transportation
Spring 2011