16.682 PS4 Answers (Updated)

1. Brayton Cycle

   1) $9.46 + (40 \cdot 9 \cdot 46) = \boxed{387.9 \text{ kg/sec}}$

   2) $\dfrac{1(44) + 2.3(18) + 3.1(32) + 19(28)}{1 + 2.3 + 3.1 + 19} = 28.2126$ g/mol

   3) $\dfrac{387,900}{716.6} = 541$ mol/sec of (Exhaust)

   CO_2: 541 mol/ sec

   H_2O: 541 2:3 = 1; 245 mol/ sec

   O_2: 541 3:1 = 1; 678 mol/ sec

   N_2: 541 19 = 10,279 mol/ sec

   4) @ 1,000K, $H_2O = 41.3$ J/(mol·K)
   $O_2 = 34.9$ J/(mol·K)
   $N_2 = 32.7$ J/(mol·K)
   $CO_2 = 54.3$ J/(mol·K)

   @ 300K, $H_2O = 32.0$ J/(mol·K)
   $O_2 = 30.1$ J/(mol·K)
   $N_2 = 29.1$ J/(mol·K)
   $CO_2 = 37.2$ J/(mol·K)

   5) Avg $H_2O = 36.7$ J/(mol·K) → Avg. from 1,000 to 300
   $O_2 = 32.5$ J/(mol·K)
   $N_2 = 30.9$J/(mol·K)
   $CO_2 = 45.8$ J/(mol·K)

   $[36.7(1,245)+32.5(1,678)+30.9(10,279)+45.8(541)]\cdot(1,000-300) = \boxed{3.09 \cdot 10^8 \text{ Watts.}}$

   6) 473 MW - 309 MW = $\boxed{164 \text{ MW}}$

   7) $n = 1 - \frac{T_c}{T_H} = 1 - \frac{400}{1000} \approx 0.6$
   $0.6 \cdot 309 \text{ MW} = \boxed{185 \text{ MW}}$

   8) $0.35 \cdot 309 = \boxed{108.2 \text{ MW}}$

→ systemic efficiency ≈ 57.5%

2) Propeller Mechanics A survey vessel has a B 5-90 propeller with a diameter (d) of 10 ft and a pitch (p) of 10 ft. The propeller speed is 200 rpm and the boat speed (V_s) is 20 knots. The thrust reduction factor (t) is 0.12, the wake fraction (w) is 0.18, and the relative rotational efficiency is 1.0. Ensure that you make SI unit conversions as necessary. If certain terms are unfamiliar, look them up in the notes or online for quick clarification. Using a B 5-90 prop curve, you determine that the constants K_T and K_Q for this propeller are:

$K_T = 0.12$ $K_Q = 0.023$ $Thrust = K_T \cdot \rho \cdot n^2 \cdot d^4$ $Torque = K_Q \cdot \rho \cdot n^2 \cdot d^5$

Where d = prop diameter, ρ = density of water, and n = speed of propeller in rev/s

(a) Propeller Advance Ratio (you should be using V_s, w, n, and d)

$$n = {}^{n_{rpm}}/_{60\ s} = 3.333\ \frac{1}{s}$$
$$V_A = V_S \cdot (1 - w) = 10.29\frac{m}{s} \cdot (1 - 0.18) = 8.44\frac{m}{s}$$

$$AR = \frac{V_A}{n \cdot d} = \frac{8.44\ {}^{m}/_{s}}{3.333\ {}^{1}/_{s} \cdot 3.048\ m} = 0.83$$

(b) Propeller Thrust (in pounds of force)

$$F_{THR} = K_T \cdot \rho \cdot n^2 \cdot d^4 = 0.12 \cdot \left(1000\ \frac{kg}{m^3}\right) \cdot (3.3333\ \frac{1}{s})^2 \cdot (3.048\ m)^4 = 115{,}080\ N = 25{,}870\ lbf$$

(c) Shaft torque (in foot-pounds)

$$Torque = K_Q \cdot \rho \cdot n^2 \cdot d^5 = 0.023 \cdot \left(1000\frac{kg}{m^3}\right) \cdot (3.333\frac{1}{s})^2 \cdot (3.048m)^5 = 67{,}228\ N \cdot m$$
$$= 49{,}580\ ft \cdot lbs$$

(d) Effective Horsepower P_E (EHP) of the Boat (*power required to overcome the vessel's resistance at the given speed)*

$$P_E = F_{THR} * (1 - t) \cdot V_S = (25{,}870 lbf) \cdot (0.88) \cdot 33.76\frac{ft}{s} \cdot \left(550\ \frac{lb \cdot \frac{ft}{sec}}{hp}\right)^{-1} = 1{,}397 hp$$

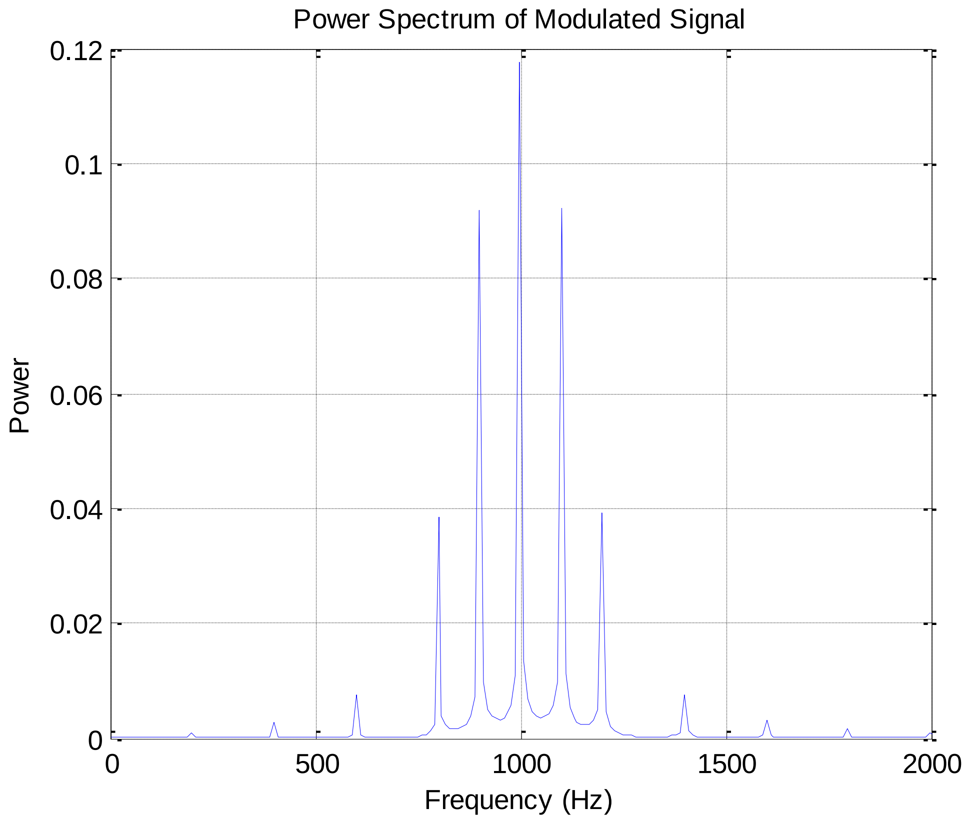
(e) Delivered Propeller Shaft horsepower (P_D) *(power actually transmitted along propeller shaft to the propeller at a particular RPM)*

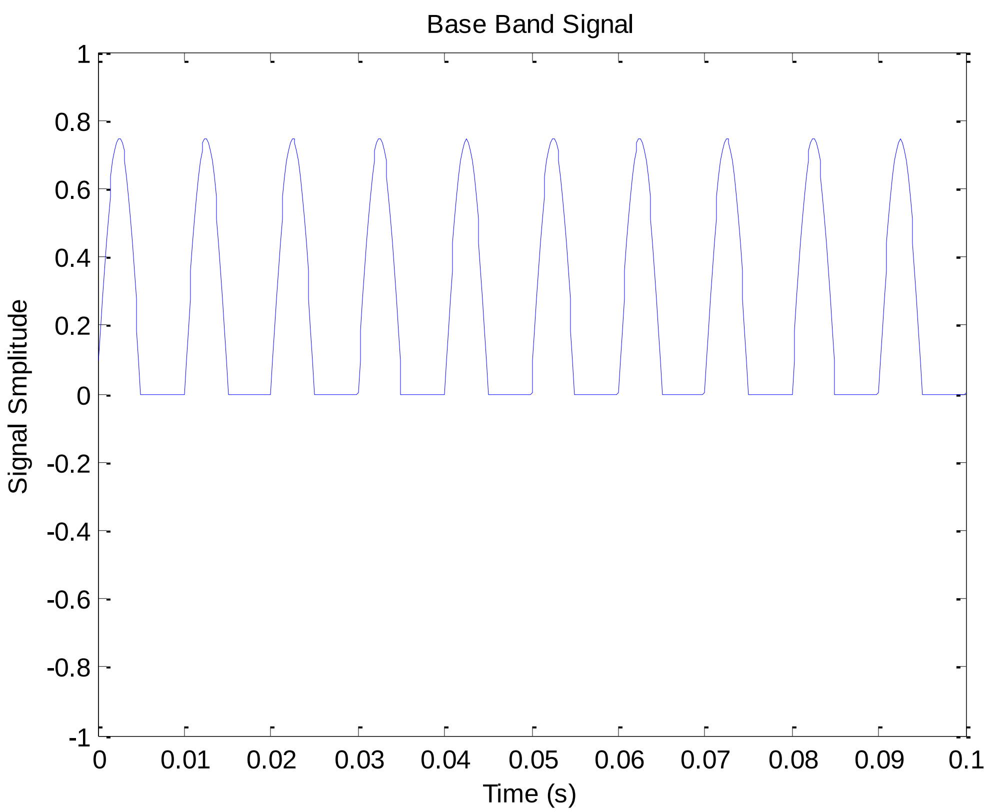
$$P_D = 2 \cdot \pi \cdot n \cdot Torque = \left(2 \cdot \pi \cdot 3.333\frac{1}{s}\right) \cdot (49{,}580 ft \cdot lbs) \cdot (550\ \frac{lb \cdot \frac{ft}{sec}}{hp})^{-1} = 1{,}888\ hp$$

(f) The Propeller Quasi Efficiency *(think about the how much we're getting out versus how much we put in*)

$$\eta_D = \frac{P_E}{P_D} = \frac{1{,}397\ hp}{1{,}888\ hp} = 0.74$$

```
%% P3Sol.m %%
% 16.682 Problem Set 4
% Signal Modulation Solution
% Note: Load variables time and modsignal

figure(1);
plot(time,modsignal);

% Fourier Transform
fs = 1/(time(2)-time(1));
m = length(modsignal);    % Window Length
n = pow2(nextpow2(m));      % Transform Length
y = fft(modsignal, n);
f = (0:n-1)*(fs/n);         % Frequency Range
power = y.*conj(y)/n;       % Power of the DFT

figure(2);
plot(f, power);
title('Power Spectrum of Modulated Signal');
xlabel('Frequency (Hz)');
ylabel('Power');


%%%% Determine that carrier frequency is 1000 Hz
%%%% by looking at plot of fourier transform

Fc = 1000;      % Estimated Carrier Frequency
carrier_signal = sin(2*pi*Fc*time);
base_band = modsignal ./ carrier_signal;
figure(3);
plot(time,base_band);
title('Base Band Signal');
xlabel('Time (s)');
ylabel('Signal Smplitude');
ylim([-1 1]);
```


Power Spectrum of Modulated Signal
Power
Frequency (Hz)
0
0.02
0.04
0.06
0.08
0.1
0.12
0
500
1000
1500
2000


Base Band Signal
Signal Smplitude
Time (s)
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1

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