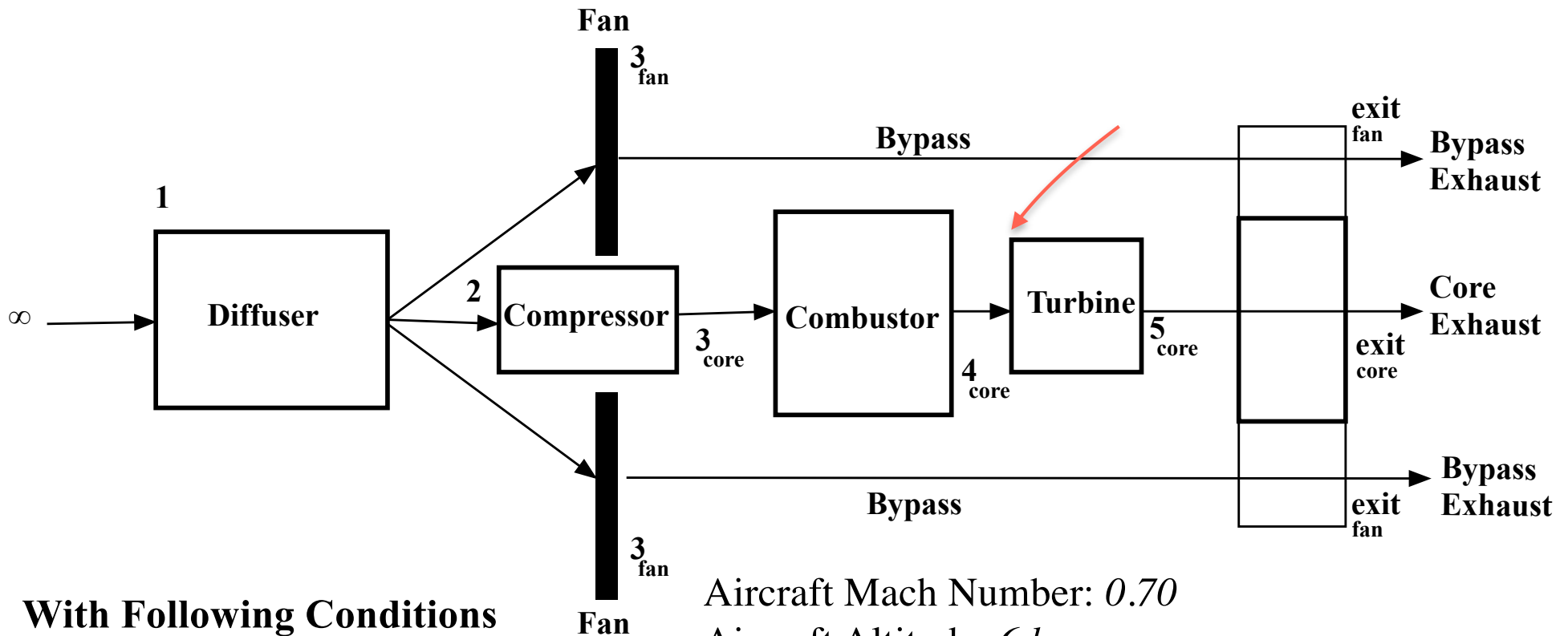


# Homework 6.2

Consider the TurboFan Engine whose Block Diagram is Shown Below



**With Following Conditions**

Aircraft Mach Number:  $0.70$

Aircraft Altitude:  $6 \text{ km}$

Bypass Ratio:  $2$

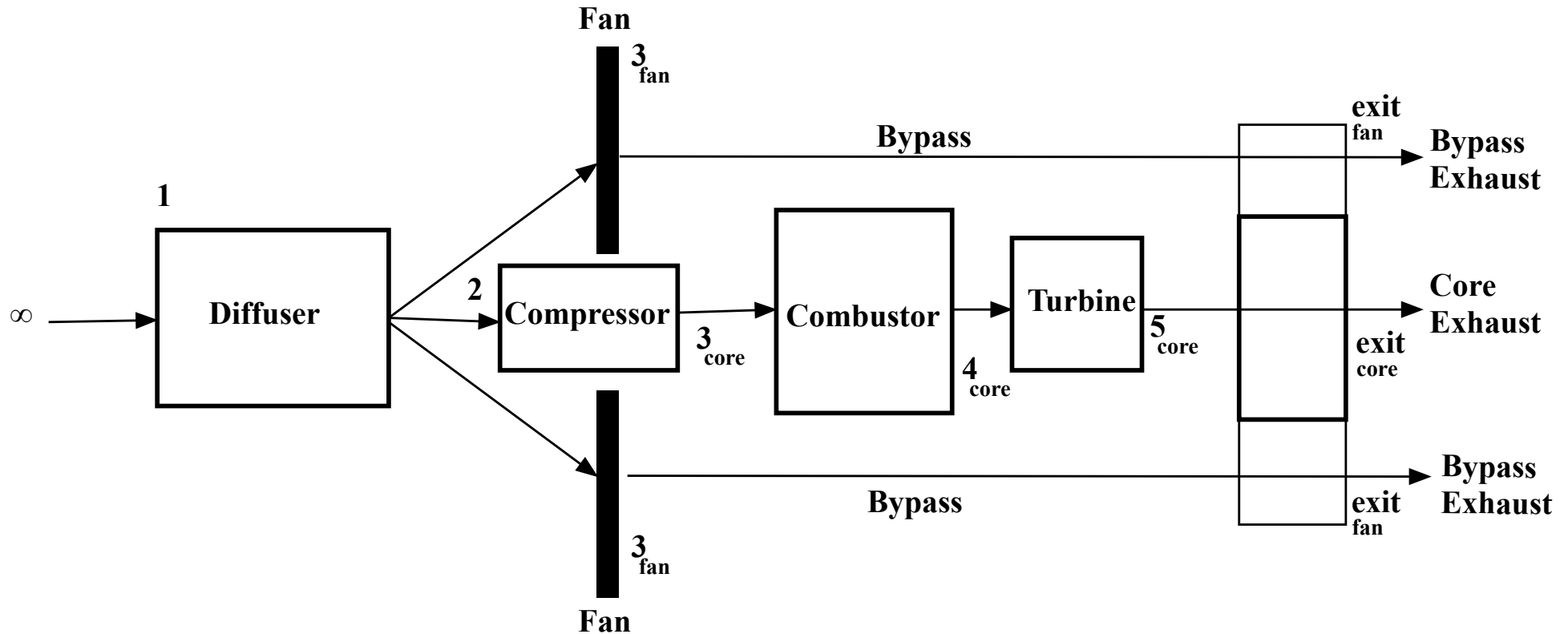
Fan Pressure Ratio:  $2$

Compressor Ratio:  $6$

Burner Outlet Temperature:  $1700 \text{ K}$

Fuel:  $JP4 \rightarrow h_f = 42.68 \text{ MJ/kg}$

# Homework 6.2 (2)



Assume the Following Component Properties

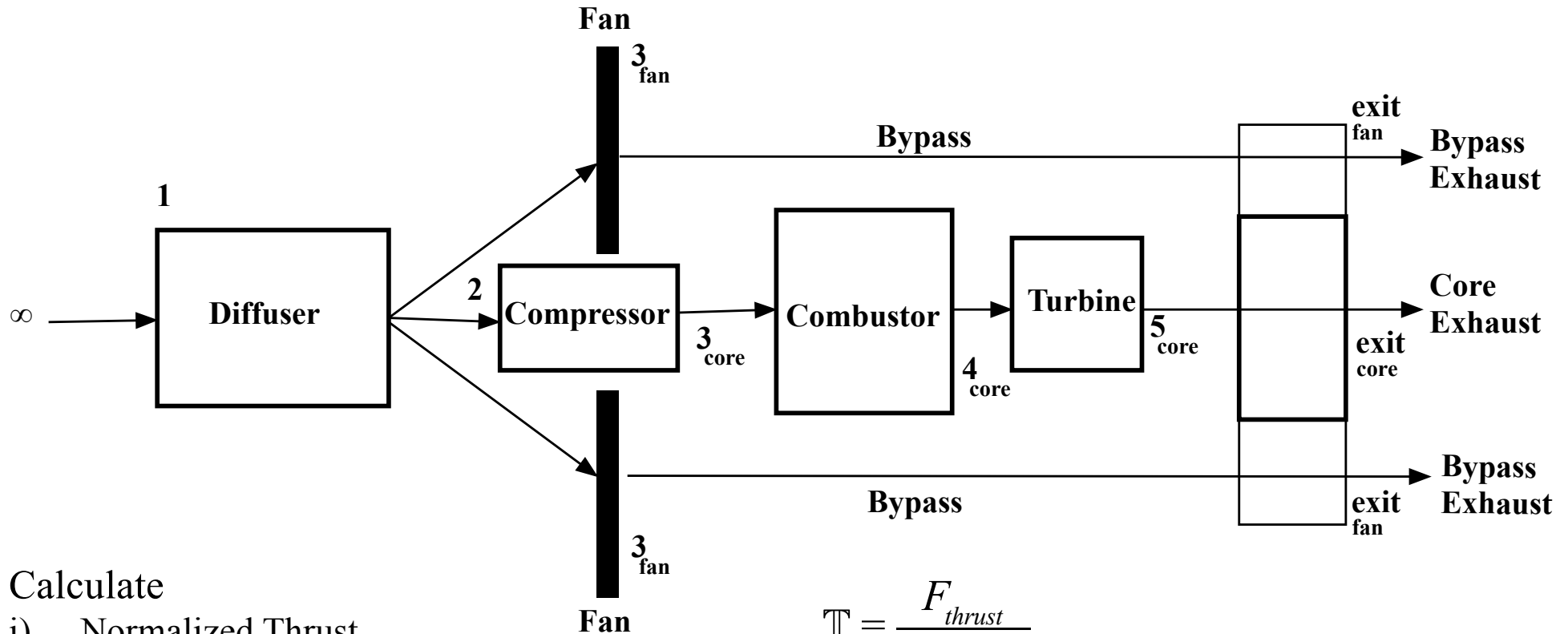
- i) Diffuser, Compressor, Fan, Turbine, Nozzle ~ Isentropic
- ii) Nozzle exit flow is NOT mixed
- iii) Combustor is 35% efficient
- iv) Fuel massflow is NOT negligible
- v) Mean specific heats, gamma are constant across engine constant
- vi) Fan, Core Nozzle Exits Optimized for Altitude

$$\rightarrow \eta_b = \frac{\dot{Q}_{3-4}}{\dot{m}_{fuel} \cdot h_f} = \tau_f \cdot \frac{C_p \cdot T_\infty}{h_f}$$

$$\gamma \approx 1.4$$

$$\rightarrow C_p \approx 1004.96 \text{ J/kg-K}$$

# Homework 6.2 (3)



Calculate

- i) Normalized Thrust
- ii) % of Thrust delivered by Core Flow
- iii) % of Thrust delivered by Bypass Flow
- ii) Ratio of Bypass Thrust to Core Thrust
- iii) Normalized Specific Impulse
- iv) TSFC *lbm/lbf-hr*
- v) *Bypass Ratio for Optimal Isp*
- vi) *Optimal TSFC*

$$\mathbb{T} = \frac{F_{thrust}}{p_{\infty} \cdot A_{\infty}}$$

$$\mathbb{II} = \frac{I_{sp} \cdot g_0}{c_{\infty}}$$

$$TSFC = \frac{1}{g_0 \cdot I_{sp}}$$



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Freestream Conditions					NonDimensional Parameters 2		Normalized Thrust, Isp	
Mach Number	Fuel Enthalpy, Kj/kg	Gamma	Core Compressor Pressure Ratio	Bypass ratio	Tau Lambda	Core Ve/Vinf	Total Normalized Thrust	
0.7	4.268E+7	1.4	6	2	6.8232	4.50474	1.26972	
Altitude, km	Cp, J/kg-K	Max Burner Temperature, K	Fan Pressure Ratio	Combustion Efficiency	Tau r	Fan Ve/Vinf	Normalized Specific Impulse	
6	1004.96	1700	2	0.35	1.098	1.85845	41.1469	
					Tau Ccore	Core Momentum Thrust	Specific Thrust, N-s/kg	
					1.66851	0.877122	13021.8	
					Tau C fan	Fan Momentum Thrust	TSFC, lbm/(lbf-hr)	
					1.2190137	0.392599	2.71115	
					Bypass Fraction	% Core Thrust		
					0.666667	0.690799		
					Tau f	% Bypass Thrust		
					59.6599	0.309201		
					Air/fuel ratio, f	(Vfan-Vinf)/(Vcore-Vinf)	ISP, SEC	
					31.7581	0.244941	1327.85	
					Tau turb	cinf, m/sec	TSFC, kg/N-sec	
					0.837303	316.472	7.67942E-5	
					Fuel/Air ratio, f2			
					0.031488			

Flight Parameters Engl			
Qc, psf	Qbar, psf	Vtrue, ft/sec	P0_inf, psf
381.45	337.99	726.70	1366.85
Pinf, psf	Tinf, R	Altitude, ft	T0_inf, R
985.40	448.47	19684.98	492.42

Ignore A/F ratio in Turbine Calculation

Yes  Value 32.677

Flight Parameters Metric			
Qc, kPa	Qbar, kPa	Vtrue, m/sec	P0_inf, kPa
18.26	16.18	221.50	65.45
Pinf, kPa	Tinf, K	CpMax	T0_inf, K
47.18	249.15	1.1286	273.57



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### Freestream Conditions

Mach Number	Fuel Enthalpy, Kj/kg	Gamma	Core Compressor Pressure Ratio	Bypass ratio
0.7	4.268E+7	1.4	6	10.16
Altitude, km	Cp, J/kg-K	Max Burner Temperature, K	Fan Pressure Ratio	Combustion Efficiency
6	1004.96	1700	2	0.35

### Flight Parameters Engl

Qc, psf	Qbar, psf	Vtrue, ft/sec	P0_inf, psf
381.45	337.99	726.70	1366.85
Pinf, psf	Tinf, R	Altitude, ft	T0_inf, R
985.40	448.47	19684.98	492.42

### Flight Parameters Metric

Qc, kPa	Qbar, kPa	Vtrue, m/sec	P0_inf, kPa
18.26	16.18	221.50	65.45
Pinf, kPa	Tinf, K	CpMax	T0_inf, K
47.18	249.15	1.1286	273.57

### NonDimensional Parameters 2

Tau Lambda	6.8232
Tau r	1.098
Tau Ccore	1.66851
Tau C fan	1.2190137
Bypass Fraction	0.910394
Tau f	59.6599
Air/fuel ratio, f	118.14
Tau turb	0.574534
Fuel/Air ratio, f2	0.0084645

Ignore A/F ratio in Turbine Calculation

Yes  Value 32.677

### Normalized Thrust, Isp

Core Ve/Vinf	Total Normalized Thrust
1.41334	0.563938
Fan Ve/Vinf	Normalized Specific Impulse
1.85845	67.9833
Core Momentum Thrust	Specific Thrust, N-s/kg
0.0278078	21514.8
Fan Momentum Thrust	TSFC, lbm/(lbf-hr)
0.53613	1.64092
Ratio Bypass to Core Thrust	% Core Thrust
19.2799	0.04931
(Vfan-Vinf)/(Vcore-Vinf)	% Bypass Thrust
2.07688	0.95069
ISP, SEC	
2193.89	
cinf, m/sec	TSFC, kg/N-sec
316.472	4.64796E-5

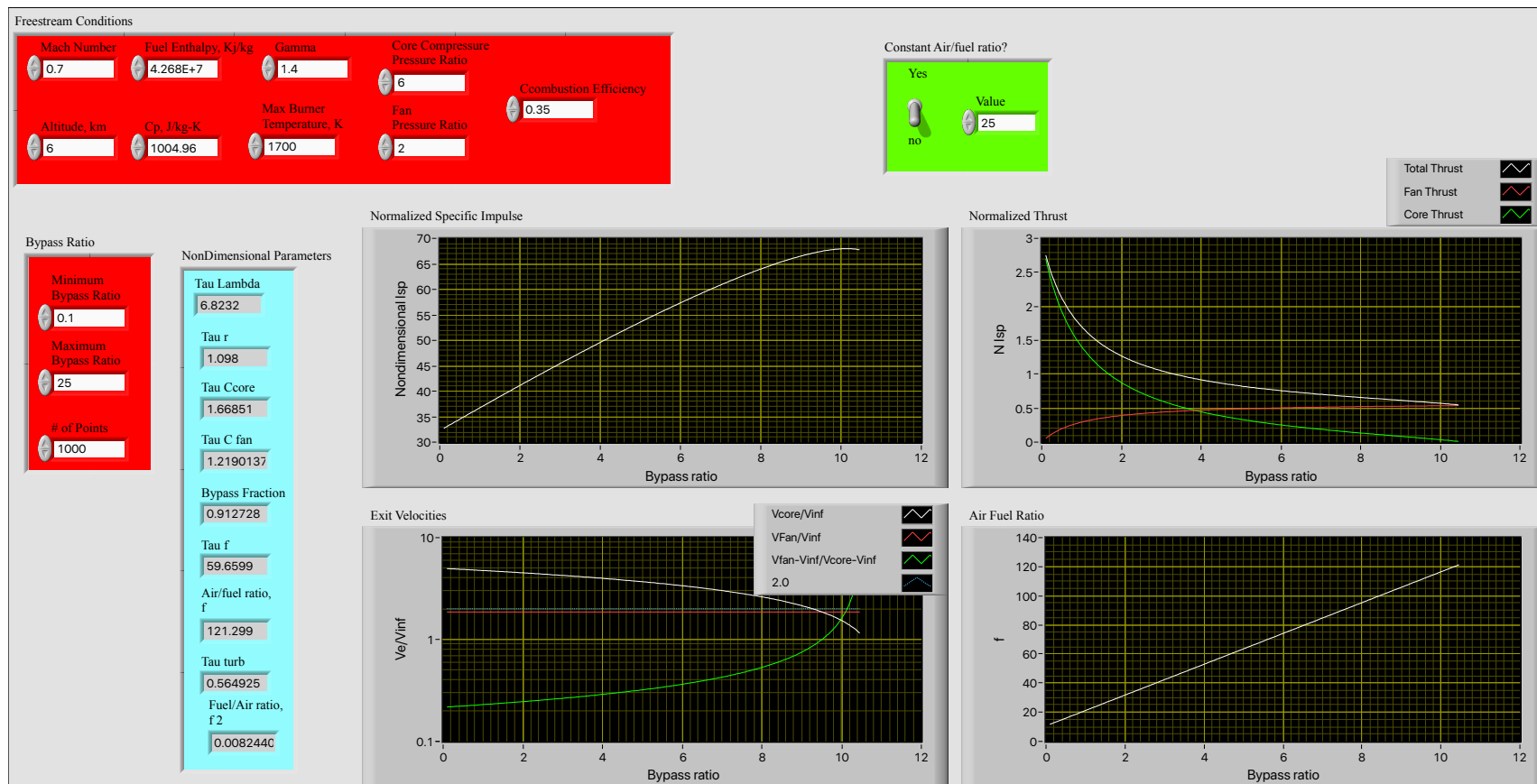


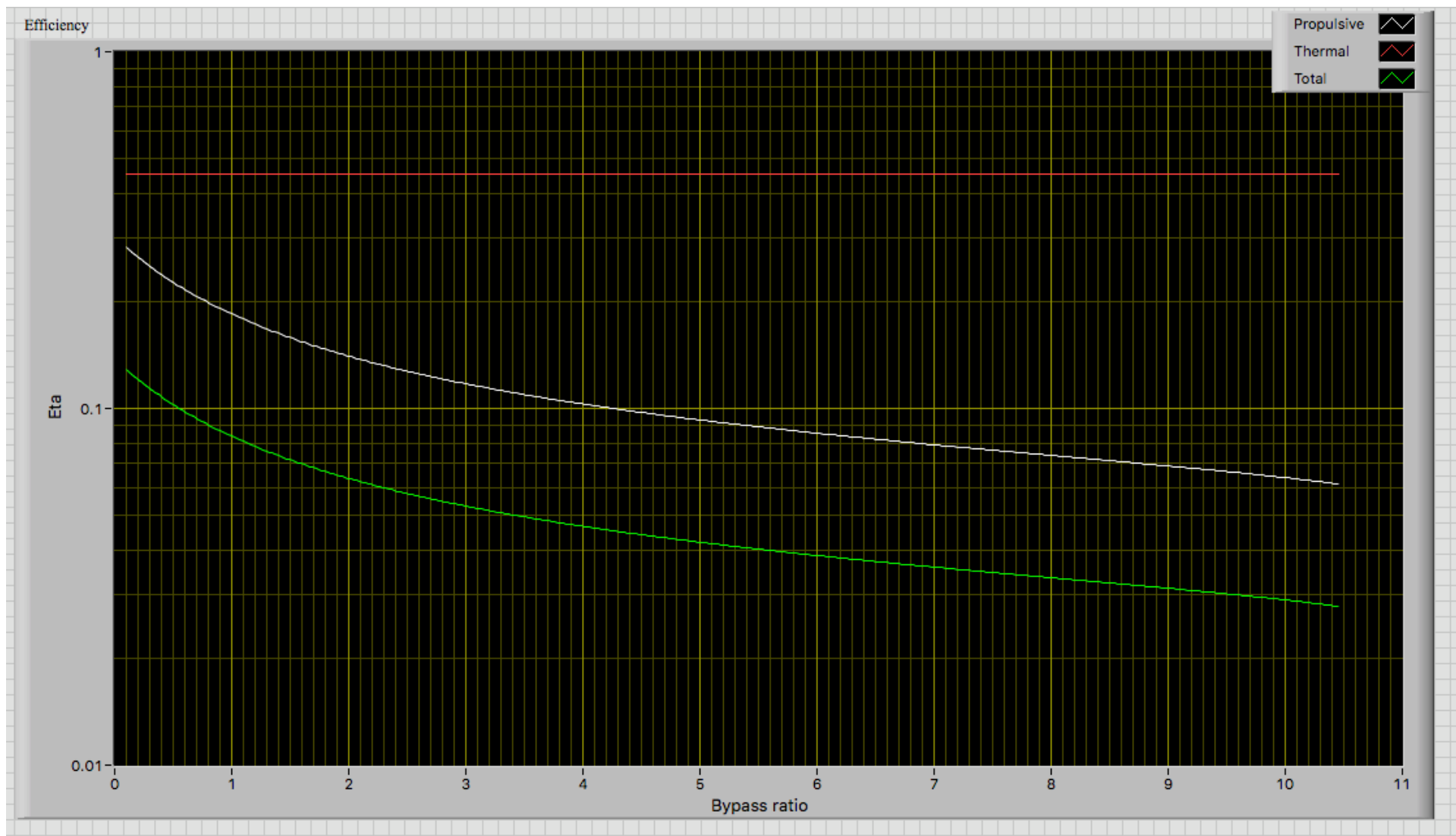
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# Questions??

