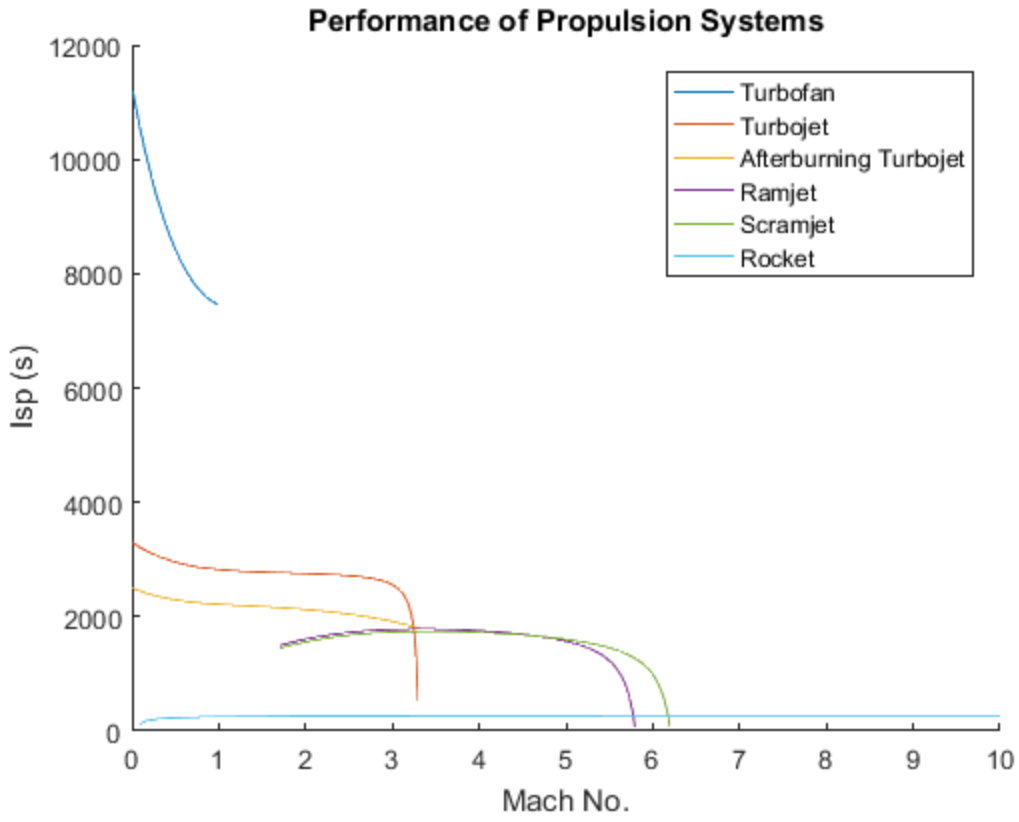
```
% Thomas Satterly
% AAE 537, HW1
% Problem 1, Part C

clc;
clear all;
close all;

import aae537.hw1.*;

M = linspace(0.01, 10, 500);

Turbofan = struct('Isp', [], 'SFC', []);
Turbojet = Turbofan;
AfterburningTurbojet = Turbofan;
Ramjet = Turbofan;
Scramjet = Turbofan;
Rocket = Turbofan;

cp = 1256; % J/kg*K
gamma = 1.4;

for i = 1:numel(M)
    [Turbofan.Isp(i), Turbofan.SFC(i)] = calcTurbofanCycle(30, 6, 2,
 gamma, cp, M(i));
    [Turbojet.Isp(i), Turbojet.SFC(i)] = calcTurbojetCycle(10, gamma,
 cp, M(i));
    [AfterburningTurbojet.Isp(i), AfterburningTurbojet.SFC(i)] =
 calcAfterburningTurbojetCycle(10, gamma, cp, M(i));
    [Ramjet.Isp(i), Ramjet.SFC(i)] = calcRamjetCycle(gamma, cp, M(i));
    [Scramjet.Isp(i), Scramjet.SFC(i)] = calcScramjetCycle(gamma, cp,
 M(i));
    [Rocket.Isp(i), Rocket.SFC(i)] = calcRocketCycle(gamma, M(i));
end

figure;
hold on;
plot(M, Turbofan.Isp);
plot(M, Turbojet.Isp);
plot(M, AfterburningTurbojet.Isp);
plot(M, Ramjet.Isp);
plot(M, Scramjet.Isp);
plot(M, Rocket.Isp);

xlabel('Mach No.');
ylabel('Isp (s)');
title('Performance of Propulsion Systems');


legend('Turbofan', 'Turbojet', 'Afterburning
 Turbojet', 'Ramjet', 'Scramjet', 'Rocket');
```

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```
function [Isp, SFC] = calcTurbofanCycle(CPR, BPR, FPR, gamma, cp, M)
% Thomas Satterly
if (M >= 1)
    Isp = nan;
    SFC = nan;
    return;
end
import aae537.hw1.*;
q_stupidUnits = 1500; % psf
q = q_stupidUnits * 47.88025; % Pa
V0 = calcSoundSpeed(gamma, 273) * M;
P0 = (2 * q) / (gamma * M^2);
Pt0 = calcStagPressure(P0, gamma, M);
T0 = 273; % K
Tt0 = calcStagTemperature(T0, gamma, M);
Tt4_f = 2600; % F
Tt4 = (Tt4_f + 459.67) * (5 / 9); % K
Hb = 18500; % BTU/lbm


% Inlet
Pt2 = Pt0 * MilStd5008B(M);
Tt2 = Tt0;

% Bypass Air Fan
Pt3f = Pt2 * FPR;
Tt3f = Tt2 * FPR^((gamma - 1) / gamma);

% Bypass air nozzle
P9f = P0;
Tt9f = Tt3f;
%V9f = sqrt(2 * cp * Tt3f * (1 - (P9f / Pt3f)^((gamma - 1) / gamma)));
V9f = sqrt(((Pt3f / P9f)^((gamma - 1) / gamma) - 1) * (2 / (gamma -
 1))) * calcSoundSpeed(gamma, (P9f / Pt3f)^((gamma - 1) / gamma) *
 Tt3f);

% Core compressor
Pt3 = Pt2 * CPR;
Tt3 = Tt2 * CPR^((gamma - 1) / gamma);

% Core combustor
Tt3_f = (Tt3 * (9 / 5)) - 459.67;
f = ((cp / 4186.798188) * (Tt4_f - Tt3_f)) / Hb;
Pt4 = Pt3;

% Core turbine
Tt5 = Tt4 - Tt3f * (1 - (1 / FPR)^((gamma - 1) / gamma)) - Tt3 * (1 -
 (1 / CPR)^((gamma - 1) / gamma));
Pt5 = Pt4 * (Tt5 / Tt4) ^ (gamma / (gamma - 1));

% Core nozzle
P9 = P0;
```

```
%V9 = sqrt(2 * cp * Tt5 * (1 - (P9 / Pt5)^((gamma - 1) / gamma)));
V9 = sqrt(((Pt5 / P9)^((gamma - 1) / gamma) - 1) * (2 / (gamma - 1)))
 * calcSoundSpeed(gamma, (P9 / Pt5)^((gamma - 1) / gamma) * Tt5);


Isp = (((1 / f) + 1) * V9 + (1 / f) * BPR * V9f - (1 / f) * (1 + BPR)
 * V0) / 9.81; % s
SFC = 1 / Isp; % 1/s


end
```

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```
function [Isp, SFC] = calcTurbojetCycle(CPR, gamma, cp, M)
% Thomas Satterly
import aae537.hw1.*;
q_stupidUnits = 1500; % psf
q = q_stupidUnits * 47.88025; % Pa
V0 = calcSoundSpeed(gamma, 273) * M;
P0 = (2 * q) / (gamma * M^2);
Pt0 = calcStagPressure(P0, gamma, M);
T0 = 273; % K
Tt0 = calcStagTemperature(T0, gamma, M);
Tt4_f = 2600; % F
Tt4 = (Tt4_f + 459.67) * (5 / 9); % K
Hb = 18500; % BTU/lbm


% Inlet
Pt2 = Pt0 * MilStd5008B(M);
Tt2 = Tt0;

% Compressor
Pt3 = Pt2 * CPR;
Tt3 = Tt2 * CPR^((gamma - 1) / gamma);

% Combustor
Tt3_f = (Tt3 * (9 / 5)) - 459.67;
f = ((cp / 4186.798188) * (Tt4_f - Tt3_f)) / Hb;
if (f <= 0)
    Isp = nan;
    SFC = nan;
    return;
end
Pt4 = Pt3;

% Turbine
Tt5 = Tt4 - ((Tt3 - Tt2) / (1 + f));
%Tt5 = Tt4 - Tt3 * (1 - (1 / CPR)^((gamma - 1) / gamma));
Pt5 = Pt4 * (Tt5 / Tt4) ^ (gamma / (gamma - 1));

% Nozzle
P9 = P0;
%V9 = sqrt(2 * cp * Tt5 * (1 - (P9 / Pt5)^((gamma - 1) / gamma)));
V9 = sqrt(((Pt5 / P9)^((gamma - 1) / gamma) - 1) * (2 / (gamma - 1)))
 * calcSoundSpeed(gamma, (P9 / Pt5)^((gamma - 1) / gamma) * Tt5);


Isp = (((1 / f) + 1) * V9 - (1 / f) * V0) / 9.81; % s
SFC = 1 / Isp; % 1/s

if ~isreal(Isp) || Isp <= 0
    Isp = nan;
    SFC = nan;
end
```

```
end
```

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```
function [Isp, SFC] = calcAfterburningTurbojetCycle(CPR, gamma, cp, M)
% Thomas Satterly
import aae537.hw1.*;
q_stupidUnits = 1500; % psf
q = q_stupidUnits * 47.88025; % Pa
V0 = calcSoundSpeed(gamma, 273) * M;
P0 = (2 * q) / (gamma * M^2);
Pt0 = calcStagPressure(P0, gamma, M);
T0 = 273; % K
Tt0 = calcStagTemperature(T0, gamma, M);
Tt4_f = 2600; % F
Tt4 = (Tt4_f + 459.67) * (5 / 9); % K
Tt6_f = 3500; % F
Tt6 = (Tt6_f + 459.67) * (5 / 9); % K
Hb = 18500; % BTU/lbm


% Inlet
Pt2 = Pt0 * MilStd5008B(M);
Tt2 = Tt0;

% Compressor
Pt3 = Pt2 * CPR;
Tt3 = Tt2 * CPR^((gamma - 1) / gamma);

% Combustor
Tt3_f = (Tt3 * (9 / 5)) - 459.67;
f_c = ((cp / 4186.798188) * (Tt4_f - Tt3_f)) / Hb;
if (f_c <= 0)
    Isp = nan;
    SFC = nan;
    return;
end
Pt4 = Pt3;

% Turbine
Tt5 = Tt4 - ((Tt3 - Tt2) / (1 + f_c));
Pt5 = Pt4 * (Tt5 / Tt4) ^ (gamma / (gamma - 1));

% Afterburner

Tt5_f = (Tt5 * (9 / 5)) - 459.67;
f_ab = ((cp / 4186.798188) * (Tt6_f - Tt5_f)) / Hb;
Pt6 = Pt5;

% Nozzle
P9 = P0;
V9 = sqrt(((Pt6 / P9)^((gamma - 1) / gamma) - 1) * (2 / (gamma - 1)))
 * calcSoundSpeed(gamma, (P9 / Pt6)^((gamma - 1) / gamma) * Tt6);

Isp = ((1 + (1 / (f_c + f_ab * (1 + f_c)))) * V9 - (1 / (f_c + f_ab *
 (1 + f_c))) * V0) / 9.81; % s
```

```
SFC = 1 / Isp; % 1/s

if ~isreal(Isp) || Isp <= 0
    Isp = nan;
    SFC = nan;
end
end
```

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```
function [Isp, SFC] = calcRamjetCycle(gamma, cp, M)
% Thomas Satterly

if (M < 1.7)
    Isp = nan;
    SFC = nan;
    return;
end

import aae537.hw1.*;
V0 = calcSoundSpeed(gamma, 273) * M;
P0 = 101325; % Pa
Pt0 = calcStagPressure(P0, gamma, M);
T0 = 273; % K
Tt0 = calcStagTemperature(T0, gamma, M);
Tt4_f = 3500; % F
Tt4 = (Tt4_f + 459.67) * (5 / 9); % K
Hb = 18500; % BTU/lbm


% Inlet
Pt2 = Pt0 * MilStd5008B(M);
Tt2 = Tt0;

% Combustor
Tt2_f = (Tt2 * (9 / 5)) - 459.67;
f = ((cp / 4186.798188) * (Tt4_f - Tt2_f)) / Hb;
if (f <= 0)
    Isp = nan;
    SFC = nan;
    return;
end
Pt4 = Pt2;

% Nozzle
P9 = P0;
V9 = sqrt(((Pt4 / P9)^((gamma - 1) / gamma) - 1) * (2 / (gamma - 1)))
 * calcSoundSpeed(gamma, (P9 / Pt4)^((gamma - 1) / gamma) * Tt4);


Isp = (((1 / f) + 1) * V9 - (1 / f) * V0) / 9.81; % s
SFC = 1 / Isp; % 1/s

if ~isreal(Isp) || Isp <= 0
    Isp = nan;
    SFC = nan;
end

end
```

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```
function [Isp, SFC] = calcScramjetCycle(gamma, cp, M)
% Thomas Satterly

if (M < 1.7)
    Isp = nan;
    SFC = nan;
    return;
end

import aae537.hw1.*;
V0 = calcSoundSpeed(gamma, 273) * M;
P0 = 101325; % Pa
Pt0 = calcStagPressure(P0, gamma, M);
T0 = 273; % K
Tt0 = calcStagTemperature(T0, gamma, M);
Tt4_f = 4000; % F
Tt4 = (Tt4_f + 459.67) * (5 / 9); % K
Hb = 18500; % BTU/lbm


% Inlet
Pt2 = Pt0 * MilStd5008B(M);
Tt2 = Tt0;

% Compressor
Pt3 = Pt2;
Tt3 = Tt2;

% Combustor
Tt3_f = (Tt3 * (9 / 5)) - 459.67;
f = ((cp / 4186.798188) * (Tt4_f - Tt3_f)) / Hb;
if (f <= 0)
    Isp = nan;
    SFC = nan;
    return;
end
Pt4 = Pt3;

% Nozzle
P9 = P0;
V9 = sqrt(((Pt4 / P9)^((gamma - 1) / gamma) - 1) * (2 / (gamma - 1)))
 * calcSoundSpeed(gamma, (P9 / Pt4)^((gamma - 1) / gamma) * Tt4);


Isp = (((1 / f) + 1) * V9 - (1 / f) * V0) / 9.81; % s
SFC = 1 / Isp; % 1/s

if ~isreal(Isp) || Isp <= 0
    Isp = nan;
    SFC = nan;
end
```

```
end
```

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```
function [Isp, SFC] = calcRocketCycle(gamma, M)
% Thomas Satterly

import aae537.hw1.*;
q_stupidUnits = 1500; % psf
q = q_stupidUnits * 47.88025; % Pa
P0 = (2 * q) / (gamma * M^2);

% Chamber
Pc = 3000; % psia
Pc = Pc * 6894.76; % Pa
Tc = 3856.23; % K

% Nozzle
Pe = P0;
if Pe > Pc
    % Impossible nozzle
    Isp = nan;
    SFC = nan;
    return;
end
Ve = sqrt(((Pc / Pe)^((gamma - 1) / gamma) - 1) * (2 / (gamma - 1))) *
 calcSoundSpeed(gamma, (Pe / Pc)^((gamma - 1) / gamma) * Tc);

Isp = Ve / 9.81;
SFC = 1 / Isp;


end
```

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```
function prat = MilStd5008B(M)
% Thomas Satterly

if (M < 1)
    prat = 1;
elseif (M >= 1) && (M < 5)
    prat = 1 - 0.075 * (M - 1)^1.35;
else
    prat = 800 / (M^4 + 935);
end

end
```

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```
function a = calcSoundSpeed(gamma, T)
% Thomas Satterly

R = 286; %m^2 /s^2*K
a = sqrt(gamma  * R * T); % m/s


end
```

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```
function Pt = calcStagPressure(P, gamma, M)
% Thomas Satterly

Pt = P * (1 + ((gamma - 1) / 2) * M^2)^(gamma / (gamma - 1));

end
```

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```
function Tt = calcStagTemperature(T, gamma, M)
% Thomas Satterly

Tt = T * (1 + ((gamma - 1) / 2) * M^2);




end
```

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