Report 6: Sample Report Prepared by MS-Word

Submitted to:
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Contents

Nomenclature

N.S. Navier Stockes
w.r.t. with respect to

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1. Problem Statement

Produce charts that describe the change of supersonic flow properties when it turned away from itself.

2. Mathematical Model

The most general governing equation is N.S. equation. This is any dummy text just to show the capabilities of nomenclatures θ of LyX w.r.t. LaTeX.

$$\mu = \sin^{-1}\left(\frac{1}{M}\right)$$
$$\left(\frac{a_0}{a}\right)^2 = 1 + \frac{\gamma - 1}{2} M^2$$

These equations are bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla

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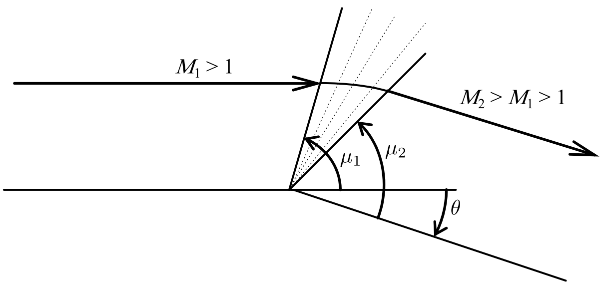
3. Assumptions

1) Steady flow
2) Quasi-dimensional flow; (area is variable with x only).
3) Bla bla bla bla bla bla bla bla bla bla bla bla.
4) Bla bla bla bla bla bla bla bla bla bla bla bla.
5) Bla bla bla bla bla bla bla bla bla bla bla bla.
6) Bla bla bla bla bla bla bla bla bla bla bla bla.
7) Bla bla bla bla bla bla bla bla bla bla bla bla.
8) Body forces can de neglected; (weight of fluid)
9) Viscous stresses are absent
10) Changes in potential energy are neglected
11) Perfect gas
12) Thermally perfect gas
13) Adiabatic flow with no external work

4. Analysis



We can derive the formula that governs super flow expansion as:

$$\nu(M_1) = \nu(M_2) + \theta$$
$$\nu(M) = \sqrt{\frac{\gamma + 1}{\gamma - 1}} \tan^{-1}\left(\sqrt{\left(\frac{\gamma - 1}{\gamma + 1}\right)(M^2 - 1)}\right) \tan^{-1}\left(\sqrt{M^2 - 1}\right)$$

4.1. Working Procedure:

If you know M_1 & θ know you can use equation (3) to solve for M_2 using Newton Raphson iteration scheme as described below:

$$M_2 = M_2 - \frac{f(M_2)}{f'(M_2)}$$

$$f(M_2) = \sqrt{\frac{\gamma+1}{\gamma-1}}\tan^{-1}\left(\sqrt{\left(\frac{\gamma-1}{\gamma+1}\right)(M^2-1)}\right) - \tan^{-1}\left(\sqrt{M^2-1}\right) - \theta - \nu(M_1)$$

$$f'\ (M_2) = \frac{M_2}{\sqrt{M_2^2-1}\left(1+\frac{\gamma-1}{\gamma+1}(M_2^2-1)\right)} - \frac{1}{M_2\sqrt{M_2^2-1}}$$

After you get M_2 you can get the pressure and temperature using the isentropic relations:

$$\frac{T_2}{T_1} = \frac{1+\frac{\gamma-1}{2}M_1^2}{1+\frac{\gamma-1}{2}M_2^2}$$

$$\frac{P_2}{P_1} = \left(\frac{T_2}{T_1}\right)^{\frac{\gamma}{\gamma-1}}$$

$$\frac{\rho_2}{\rho_1} = \left(\frac{T_2}{T_1}\right)^{\frac{1}{\gamma-1}}$$

$$P_{01} = P_{02} = P_0$$

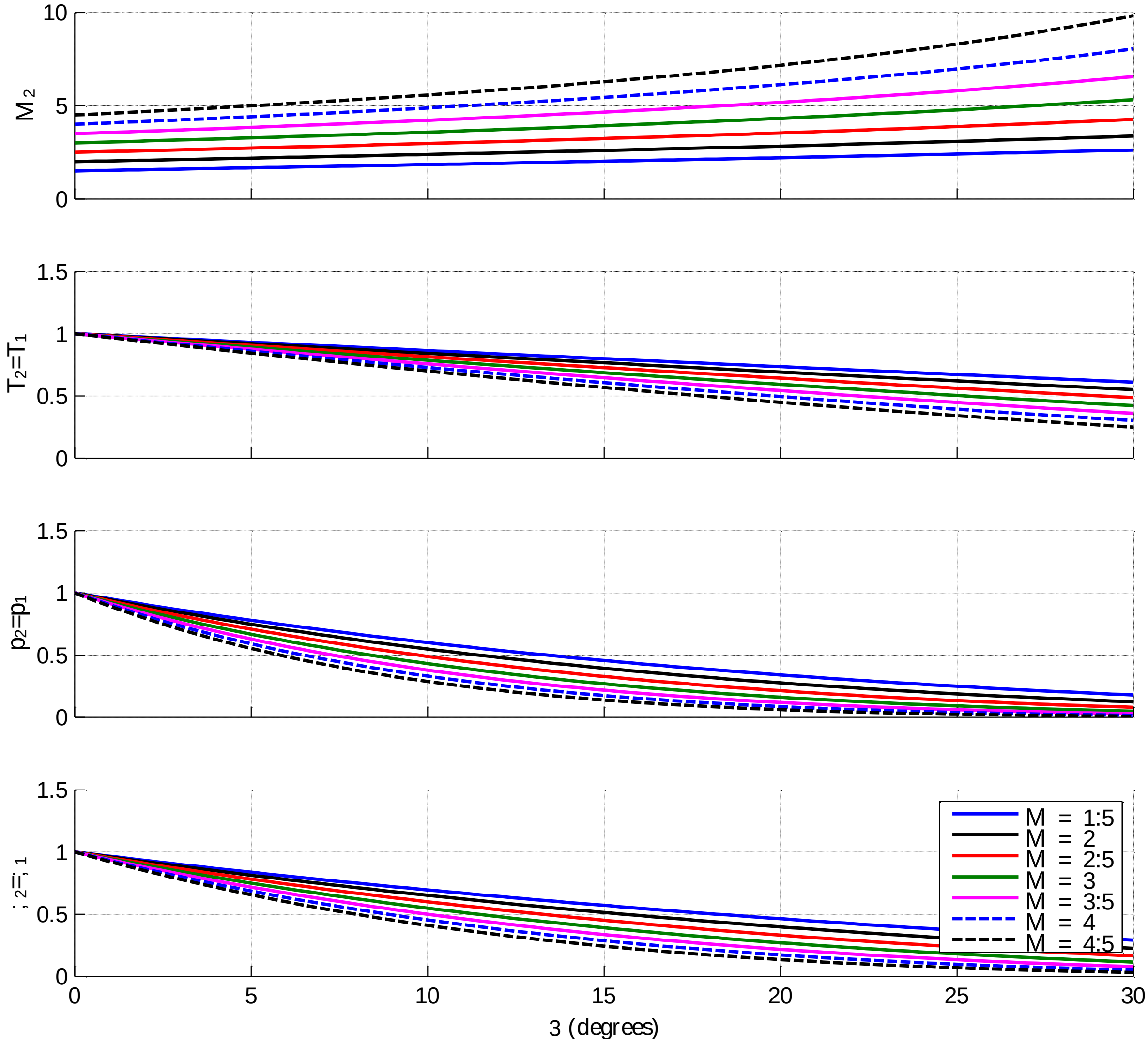
Function M_2o.m [Code 2] illustrates this procedure. Report6 main.m [Code 1] was used to plot the figures shown in section 4.2. Report6 main.m [Code 3] is just for exporting the figure to a pdf or emf to be included in section 4.2. Therefore this code is not complete.

This is a line with some Arabic words هذا هو بعض الكلمات العربية فى سطر انجليزى.

و هذا سطر عربى به بعض الكلمات الانجليزية.Thus is some English words in an Arabic line.

و بناءً عليه فقد تم اثبات المطلوب. و بناءً عليه فقد تم اثبات المطلوب. و بناءً عليه فقد تم اثبات المطلوب. و بناءً عليه فقد تم اثبات المطلوب. و بناءً عليه فقد تم اثبات المطلوب. و بناءً عليه فقد تم اثبات المطلوب. و بناءً عليه فقد تم اثبات المطلوب. و بناءً عليه فقد تم اثبات المطلوب. و بناءً عليه فقد تم اثبات المطلوب. و بناءً عليه فقد تم اثبات المطلوب. و بناءً عليه فقد تم اثبات المطلوب. و بناءً عليه فقد تم اثبات المطلوب.

4.2. Results



The following table is just for demonstration. It doesn't provide any useful information.

Angle (θ)	Temperature	Pressure	Density
12	324	6780	7676
12	232	232	7565
23	12121	232	4654

5. Conclusion

We see that we can still obtain solutions for M_2 for $\theta > 90^{\circ}$. But, however I think the solutions for $\theta > 90^{\circ}$ aren't practical.

Pressure, temperature & density increases as the kinetic energy increase as in [1].

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Appendices

A. Matlab Codes

Code 1: Report6 main.m

```
function M_2_vec=M_2o(M_1,theta_d_vec, ...
                      gamma)     %optional arguments
if nargin<3
    gamma=1.4;
end

theta_vec=deg2rad(theta_d_vec);
n1=sqrt((gamma+1)/(gamma-1))*atan(sqrt((gamma-1)/(gamma+1)*(M_1^2-1)))-
atan(sqrt(M_1^2-1));

%Newton Raphson iteration
M_2_vec=1.1*ones(size(theta_d_vec));
for ii=1:length(theta_d_vec)
    f=sqrt((gamma+1)/(gamma-1))*atan(sqrt((gamma-
1)/(gamma+1)*(M_2_vec(ii)^2-1)))-atan(sqrt(M_2_vec(ii)^2-1))-theta_vec(ii)-
n1;
    fdash=1/(M_2_vec(ii)^2-1)^(1/2)*M_2_vec(ii)/(1+(gamma-
1)/(gamma+1)*(M_2_vec(ii)^2-1))-1/(M_2_vec(ii)^2-1)^(1/2)/M_2_vec(ii);

    M_2_n=M_2_vec(ii)-f/fdash;
    while abs(M_2_vec(ii)-M_2_n)>=100*eps %This is dangerous. Infinte loop
can occur!!
        M_2_vec(ii)=M_2_n;
        f=sqrt((gamma+1)/(gamma-1))*atan(sqrt((gamma-
1)/(gamma+1)*(M_2_vec(ii)^2-1)))-atan(sqrt(M_2_vec(ii)^2-1))-theta_vec(ii)-
n1;
        fdash=1/(M_2_vec(ii)^2-1)^(1/2)*M_2_vec(ii)/(1+(gamma-
1)/(gamma+1)*(M_2_vec(ii)^2-1))-1/(M_2_vec(ii)^2-1)^(1/2)/M_2_vec(ii);
        M_2_n=M_2_vec(ii)-f./fdash;
    end
    M_2_vec(ii)=M_2_n;
end
```

Code 2: Function M_2o.m

```
function M_2_vec=M_2o(M_1,theta_d_vec, ...
                      gamma)     %optional arguments
if nargin<3
    gamma=1.4;
end

theta_vec=deg2rad(theta_d_vec);
n1=sqrt((gamma+1)/(gamma-1))*atan(sqrt((gamma-
1)/(gamma+1)*(M_1^2-1)))-atan(sqrt(M_1^2-1));

%Newton Raphson iteration
M_2_vec=1.1*ones(size(theta_d_vec));
for ii=1:length(theta_d_vec)
    f=sqrt((gamma+1)/(gamma-1))*atan(sqrt((gamma-
1)/(gamma+1)*(M_2_vec(ii)^2-1)))-atan(sqrt(M_2_vec(ii)^2-1))-
theta_vec(ii)-n1;
```

```
    fdash=1/(M_2_vec(ii)^2-1)^(1/2)*M_2_vec(ii)/(1+(gamma-
1)/(gamma+1)*(M_2_vec(ii)^2-1))-1/(M_2_vec(ii)^2-
1)^(1/2)/M_2_vec(ii);

    M_2_n=M_2_vec(ii)-f/fdash;
    while abs(M_2_vec(ii)-M_2_n)>=100*eps %This is dangerous.
Infinte loop can occur!!
        M_2_vec(ii)=M_2_n;
        f=sqrt((gamma+1)/(gamma-1))*atan(sqrt((gamma-
1)/(gamma+1)*(M_2_vec(ii)^2-1)))-atan(sqrt(M_2_vec(ii)^2-1))-
theta_vec(ii)-n1;
        fdash=1/(M_2_vec(ii)^2-1)^(1/2)*M_2_vec(ii)/(1+(gamma-
1)/(gamma+1)*(M_2_vec(ii)^2-1))-1/(M_2_vec(ii)^2-
1)^(1/2)/M_2_vec(ii);
        M_2_n=M_2_vec(ii)-f./fdash;
    end
    M_2_vec(ii)=M_2_n;
end
```

Code 3: Function export_figure

```
unction export_figure(h_vec,  ...
                    Expand,filenames,resolution,pictureFormat)
%Optional arguments

if nargin<2
    Expand='';
end

if nargin<4
    resolution=600;
elseif isempty(resolution)
    resolution=600;
end

if nargin<5
    pictureFormat={'pdf'};
else
    if ~iscell(pictureFormat)
        error('pictureFormat must be cell array of strings.')
    end
end

%%% A lot more code
```

References

[1] J. D. Anderson, Modern Compressible Flow, McGraw-Hill, New York, 1990.
[2] Report (1).
[3] Report (3).