HW9

April 4, 2024

1 HW 9

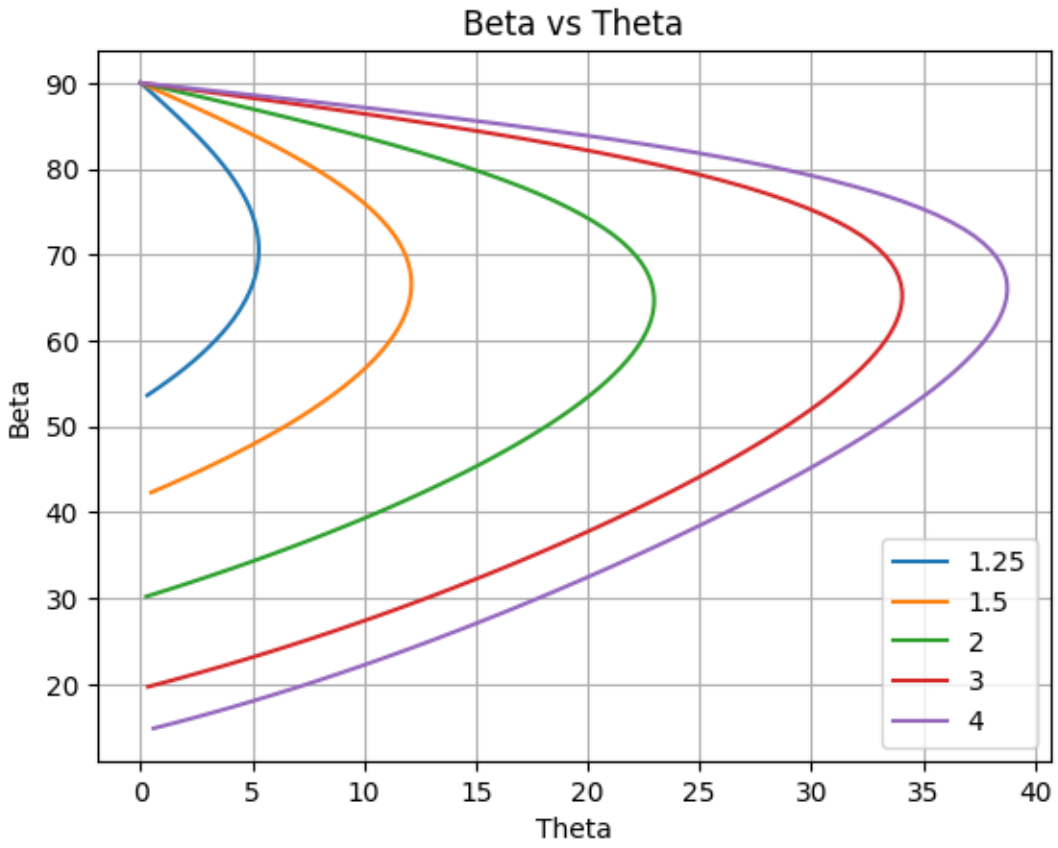
[3]:
```
%%capture
import platform

import __init__ as CFC

import math
import numpy as np
import matplotlib.pyplot as plt

import math
from scipy.optimize import root_scalar
```

1.1 9.2 Oblique Shock Polar

[4]:
```
machs = [1.25, 1.5, 2, 3, 4]
gamma = 1.4
```

[5]:
```
betas = np.linspace(math.radians(10), math.pi / 2, 100)

for mach in machs:
  results = []

  for beta in betas:
    res = CFC.ThetaBetaMach(gamma, mach=mach, beta=beta)
    if res.theta > 0:
      results.append(res)

  bs = [math.degrees(res.beta) for res in results]
  ts = [math.degrees(res.theta) for res in results]

  plt.plot(ts, bs, label=mach)  # Swap the order of the variables
plt.xlabel('Theta')  # Update the label
plt.ylabel('Beta')  # Update the label
plt.title('Beta vs Theta')  # Update the title
plt.legend()  # Add a legend
```

```
plt.grid(True)  # Add a grid
plt.show()
```



1.2 9.3 Wind Tunnel Testing

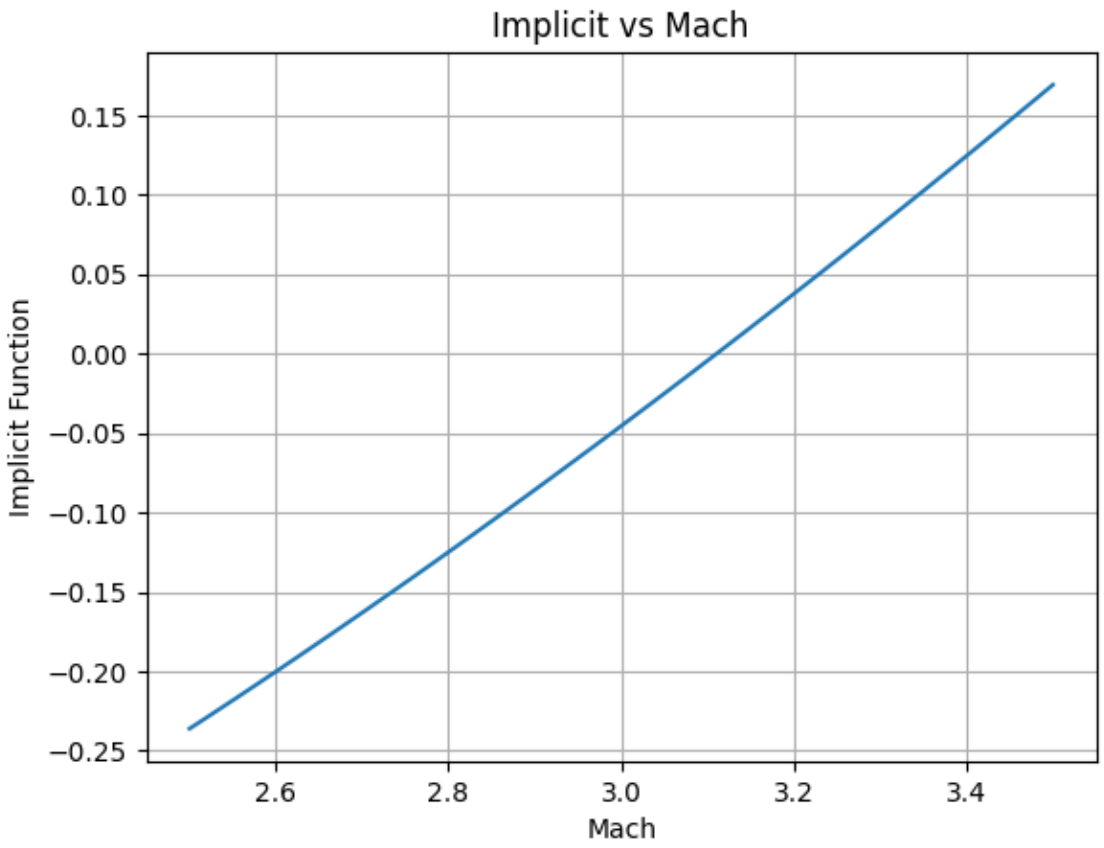
1.2.1 9.3 a)

[7]:
```
nitrogen_gamma = 1.470

shock_angle = math.radians(20)
surface_angle = math.radians(10)

tbm = CFC.ThetaBetaMach(nitrogen_gamma, beta=shock_angle, theta=surface_angle)
tbm
```

[7]:
```
Theta: 0.174533
Beta:  0.349066
Mach:  4.850817
```

1.2.2 9.3 b)

[8]:
```
air_gamma = 1.4

p_infin = 4e3
p_surf = 8.4e3

def p_two_over_infin(gamma, mach, theta):
  return CFC.ObliqueShock(gamma, mach=mach, theta=theta).shock_ratio.
 ↪pressure_ratio

machs = []
implicits = []

for mach in np.linspace(2.5, 3.5):
  try:
    implicit = p_two_over_infin(air_gamma, mach, surface_angle) - p_surf /␣
 ↪p_infin
  except:
    implicit = None

  if implicit is not None:
    implicits.append(implicit)
    machs.append(mach)

plt.plot(machs, implicits)
plt.xlabel('Mach')
plt.ylabel('Implicit Function')
plt.title('Implicit vs Mach')
plt.grid(True)
plt.show()

mach = root_scalar(lambda m: p_two_over_infin(air_gamma, m, surface_angle) -␣
 ↪p_surf / p_infin, bracket=[2.5, 3.5]).root
mach
```



[8]: 3.1105320871909106

```
Executing <Task pending name='Task-4' coro=<Kernel.dispatch_queue() running at
/Users/wmac/Library/Python/3.12/lib/python/site-
packages/ipykernel/kernelbase.py:524> wait_for=<Future pending
cb=[Task.task_wakeup()] created at
/Users/wmac/Library/Python/3.12/lib/python/site-packages/tornado/queues.py:248>
cb=[IOLoop.add_future.<locals>.<lambda>() at
/Users/wmac/Library/Python/3.12/lib/python/site-packages/tornado/ioloop.py:685]
created at /Library/Frameworks/Python.framework/Versions/3.12/lib/python3.12/asy
ncio/tasks.py:685> took 0.331 seconds
```

1.3 9.4 Supersonic Expansion

[9]:
```
mach_one = 2
p_one = 45e3
T_one = 250

p_two = 12e3
```

```
def p_two_over_one(gamma, mach_one, mach_two):
  p_stag_over_one = CFC.IsentropicRatio(gamma, mach_one).pressure_ratio
  p_stag_over_two = CFC.IsentropicRatio(gamma, mach_two).pressure_ratio

  return p_stag_over_one / p_stag_over_two

mach_two = root_scalar(lambda m: p_two_over_one(air_gamma, mach_one, m) - p_two␣
 ↪/ p_one, bracket=[2.5, 3.5]).root
mach_two
```

[9]: 2.851245065152407

[10]:
```
pm = CFC.PrandtlMeyer(gamma, mach_one=mach_one, mach_two=mach_two)
print(f"theta: {math.degrees(pm.theta):.3f}")
```

```
theta: 20.424
```

[ ]: