

AE352 Quiz 1

Question 1

$$C: 12 \text{ amu} = 1.992 \times 10^{-26}$$

$$O: 16 \text{ amu} = 2.656 \times 10^{-26}$$

a) equations of motion

$$m_0 \ddot{x}_0 = -kx_1 + k(x_2 - x_1)$$

$$m_C \ddot{x}_C = -k(x_2 - x_1) - k(x_2 - x_3)$$

$$m_O \ddot{x}_O = -k(x_3 - x_2) + kx_3$$

$$x_0 = x_1$$

$$x_C = x_2$$

$$x_O = x_3$$

$$M\ddot{x} = -Kx$$

$$\begin{bmatrix} m & 0 & 0 \\ 0 & m & 0 \\ 0 & 0 & m \end{bmatrix} \begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = -k \begin{bmatrix} 1 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

b) Using code

```

import numpy as np
from scipy.linalg import eig

# Constants
k = 1500 # spring constant in N/m
m_C = 12 * 1.66e-27 # mass of carbon atom in kg
m_O = 16 * 1.66e-27 # mass of oxygen atom in kg

M = np.diag([m_0, m_C, m_O]) # diagonal matrix of masses
K = k * np.array([[1, -1, 0], [-1, 2, -1], [0, -1, 1]]) # stiffness matrix

eigenvalues, eigenvectors = eig(K, M)

print(eigenvalues)
print(eigenvectors)

angular_frequencies = np.sqrt(np.real(eigenvalues))

angular_frequencies_sorted = np.sort(angular_frequencies)

angular_frequencies_sorted

```

eigenmodes

]
] M & K matrices
] are used
] eigenvector/eigenvalues

] following the equation
(K - w²M)A = 0

w² the "eigenvalue"
but has to be square root
to get w

angular frequencies (rad/s)

C)

```

frequencies = angular_frequencies_sorted / (2 * np.pi)

c = 299792458 # in m/s

wavelengths = c / frequencies

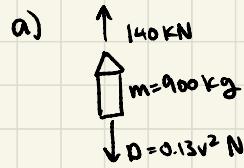
print(wavelengths)

```

[9.95126211e+02 7.92627210e-06 4.13936060e-06]

wavelengths (m)

AE352 Quiz 1



Question 2

Maximum

$$\text{Thrust} = 140 \text{ kN} = 140,000 \text{ N}$$

$$\sum F: T = D$$

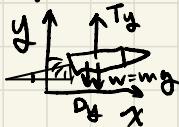
$$140,000 = 0.13v^2$$

$$v^2 = 1016923.077$$

$$\star v = 1037.749 \text{ m/s}$$

maximum airspeed

b)



$$T_y = T \sin(\alpha)$$

$$\sum F: T_y = W = mg$$

$$T \sin(\alpha) = mg$$

$$\sin(\alpha) = \frac{(900)(9.81)}{140000}$$

$$\star \alpha = 3.615^\circ$$