Stanford | ENGINEERING
Aeronautics and Astronautics

AA179 (Spring 2024)
Problem Set 1
Total of 100 points
Due on April 15, 2024, at 6 pm Pacific Time

1) Euler angles and rotation matrices (15 points)

1.a) Write the analytical expression for the final rotation matrix $\mathbf{R}$ for the following rotations:

- first, rotate around the *Z*-axis by angle γ
- then rotate around the *Y*-axis by angle β
- finally, rotate around the *X*-axis by angle α

Use the passive definition, where we rotate the coordinate system.

2) Coordinate transformations give (20 points)

The Durand Building geodetic coordinates are given below:

Geodetic latitude, *B*	$37^\circ 25^\mathrm{m} 37.72^\mathrm{s}$
Geodetic longitude, *L*	$-122^\circ 10^\mathrm{m} 26.01^\mathrm{s}$
Geodetic height, *H*	35 meters

2.a) Transform these geodetic coordinates to the Cartesian Earth-centered Earth-fixed coordinates.

2.b) How far is Durand from the center of the Earth?

(For extra 5 points)
***2.c)** What is the elevation above local horizon of the top of the Berkeley Campanile tower as observed from the top of the Stanford Hoover tower? Use Google Earth to get the coordinates of the ground levels. Explain how you derived the answer.*

3) Visibility of the International Space Station (ISS) (25 points)

You are located at Stanford University, and you observe the sky with an unaided eye. The time stamps and coordinates of the ISS are given in the file *ISS_coords.txt in the Data folder* on Canvas. The coordinates are given in the Earth-fixed Cartesian coordinate system. Time is given in days in year 2024 using Universal Time.

3.a) How high will the ISS reach in the sky?

3.b) How much time will it take for ISS to cross the sky?

3.c) Will you be able to see the ISS given the information provided in this problem? What other information might you need to figure out visibility of ISS?

4) Solar Eclipse (15 points)

The magnitude of eclipse is the fraction of the angular diameter of a celestial body being eclipsed (see Fig. 1).

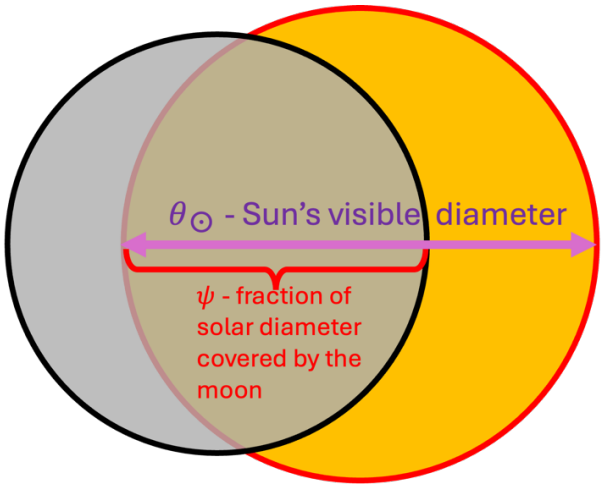

Figure 1. Illustration of the eclipse geometry. The eclipse magnitude is defined as $\psi/\theta_\odot$

The eccentricity of the lunar orbit is 0.055.
The semimajor axis of the lunar orbit is 384,000 km.
The eccentricity of the Earth orbit is 0.017.
The semimajor axis of the Earth orbit is 149,600,000 km

4.a) What is the maximum possible total eclipse magnitude?

4.b) What is the minimum possible annular eclipse magnitude?

4.c) You might have seen this recently:
https://www.nasa.gov/blogs/missions/2025/03/14/nasa-science-data-received-blue-ghost-captures-eclipse-from-moon/
What is the maximum possible solar eclipse magnitude observed from the moon, when the Earth covers the disk of the Sun?

(For extra 10 points)
***4.d)** Given scripts from the eclipse lecture, compute the duration of the April 8, 2024 eclipse in Austin, Texas. Provide your answer in seconds.*

5) Observing rocket launches from Stanford (25 points)

The coordinates of the Durand Building and the Vandenburg Air Force Base are given below:

Coordinates of the Durand Building

Geodetic latitude, *B*	$37^\circ 25^\mathrm{m} 37.72^\mathrm{s}$
Geodetic longitude, *L*	$-122^\circ 10^\mathrm{m} 26.01^\mathrm{s}$
Geodetic height, *H*	35 meters

Coordinates of the Vandenberg Air Force Base

Geodetic latitude, *B*	$34^{\circ}45^{\mathrm{m}}20.09^{\mathrm{s}}$
Geodetic longitude, *L*	$-120^{\circ}37^{\mathrm{m}}20.91^{\mathrm{s}}$
Geodetic height, *H*	56 meters

5.a) What is the azimuth and elevation of the Vandenburg Air Force base as observed from the Durand Building?

5.b) What is the minimum altitude of a rocket going vertically up that it would appear above local horizon at Stanford.

Hint: you can solve this question graphically in Python/Jupyter. No analytical derivation needed (you are welcome to derive it ☺).

5.c) Can you observe rocket launches from the 4th floor balcony of the Durand building? Justify your answer by a visual reconnaissance of the horizon from the balcony.

5.d) What is the optimal place to observe the Vandenburg rocket launches in the vicinity of Stanford's campus and besides the spot mentioned in the syllabus? Justify your answer. If you are interested, you can find the schedule of launches here: https://spaceflightnow.com/launch-schedule/

Hint: in order to observe the rocket launch, there should at least be a direct unobstructed line of sight to the rocket.