ME 51500/I5800 L | Final Exam | P. Ganatos
135 min. | Closed Book, Open Notes* | 12/20/2022

Only original handwritten notes and homeworks are allowed. Photocopied notes and homework/exam solution sheets are <u>not</u> permitted. Except for a hand calculator, no cell phone or electronic equipment of any kind is allowed.

<u>SHOW ALL WORK</u> AND GIVE <u>UNITS</u> IN FINAL ANSWERS.

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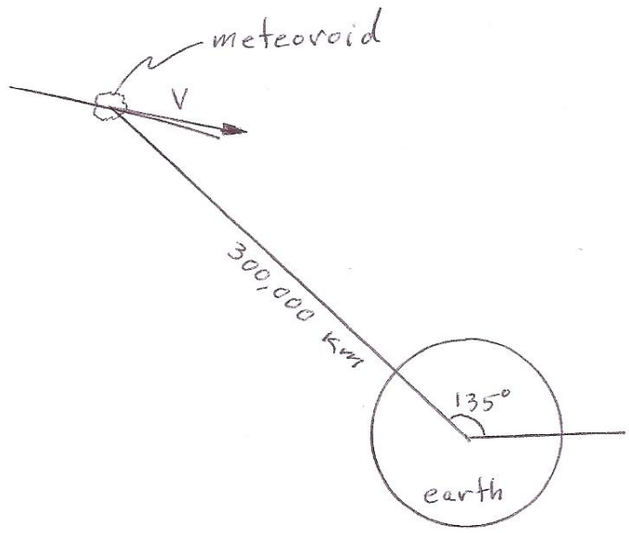
[35] 1. A meteoroid is first observed approaching the earth when it is 300,000 km from the center of the earth with a true anomaly of 135°, as shown in the figure below. If the geocentric speed of the meteoroid V is 2.5 km/sec when it is first observed, determine:

a) Whether the trajectory is elliptic, parabolic or hyperbolic. [5 points]
b) The orbital elements a and e of the trajectory. [10 points]
c) Whether the meteoroid flies by or strikes the earth. [5 points]
d) The time until the meteoroid reaches its closest approach to the earth or strikes the earth. [10 points]
e) Draw the trajectory of the meteoroid on the hodographic plane and label the point where the meteoroid is first observed and the point referred to in part (d). [5 points]



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[40] 2. Consider the earth and Venus to be in coplanar circular orbits of radii 1 au and 0.7233 au, respectively. For a transfer angle $\Delta\theta = 120°$

a) Calculate the transfer time of the minimum energy transfer ellipse. [10 points]
b) Calculate the lag angle β_{12} of Venus at the time of launch with respect to the earth for interception with Venus to occur. [10 points]
c) Calculate the linear distance between the earth and Venus at the time of arrival. [10 points]
d) Draw an accurate labeled sketch which includes the earth and Venus orbits about the sun, the positions of earth and Venus at launch and at arrival, the transfer trajectory, and the angles $\Delta\theta$ and β_{12}. [10 points]

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[25] 3. A spacecraft is launched from earth into a heliocentric orbit having a period of exactly one-half year, allowing a flyby of the earth one year after launch.

a) Find the semi-major axis and eccentricity of the (pre-flyby) spacecraft orbit. [10 points]
b) If the intention is to send the spacecraft to the outer solar system, should the spacecraft pass over the sunlit side or the dark side of the earth? [5 points]
c) If the earth flyby occurs at an altitude of 560 km, calculate the increase in velocity resulting from the flyby. [10 points]

(Astronomical constants on back side)

Astronomical Constants

The Sun

Mass = 1.989 x 10^{30} kg
Radius = 395,990 km
$\mu_{sun} = Gm_{sun} = 4\pi^2$ au^3/yr^2 = 1.327×10^{11} km^3/sec^2

The Earth

Mass = 5.974×10^{24} kg
Radius = 6378 km
$\mu_{earth} = Gm_{earth} = 3.986 \times 10^5$ km^3/sec^2
Mean distance from sun = 1 au = 1.496×10^8 km
1 year = 365.26 days

Venus

Mass = 4.868×10^{24} kg
Radius = 6053 km
$\mu_{Venus} = Gm_{Venus} = 3.248 \times 10^5$ km^3/sec^2
Mean distance from sun = 0.7233 au