PHY2003 Astrophysics I – Assignment 2

As explained in Level 2 induction, submission of this assignment will be via Canvas. If your document is illegible you will not receive any marks. Your completed assignment must be submitted as a scanned PDF file. A smartphone with a high pixel-count camera scanner app producing pdfs is also an acceptable scanning method. Microsoft Office Lens will automatically upload the images as a pdf: You can find a Microsoft Office Lens Tutorial here. Alternatively, you can use the scanners in the McClay Library to scan your completed assignment.

Show all calculations/steps in your answers for the questions/tasks below. The deadline is 10pm, Wednesday October 27, 2021 but you can submit at any time before then.

Orbits (100 points)

A list of some of the first asteroids discovered, and their orbital parameters, is given on the last page. Take the last digit of your student number. Find the asteroid, on the last page, that also shares your number as the last number in its designation number. This is the asteroid you should use to complete the assignment below. (i.e. if your student number is 87654321, you would use asteroid 41 Daphne).

For your asteroid number write down the number, name, diameter, albedo, semimajor axis (a), and orbital eccentricity (e) on the top of your paper. (2 points)

1. Assuming a bulk density close to rock (2.2 g/cm^3), estimate the mass of your asteroid. Assuming a bulk density for a rocky rubble pile (1.5 g/cm^3), estimate the mass of your asteroid. (5 points)

2. Assume that the asteroid is at opposition, when the Sun, Earth and asteroid all lie on the same line and the Earth is directly between the Sun and the asteroid. If at that time the asteroid and the Earth are at their mean distances from the Sun, what is the asteroids' distance from the Earth in au and in km? (10 points)

3. Calculate the perihelion and aphelion distances of your asteroid in au, and the orbital velocities at those points. (20 points)

4. Calculate the minimum distance between the Earth's orbit and your asteroid's orbit, assuming the Earth's orbit as circular and both orbits are co-planar (i.e. i = 0°). The 8.2-m Very Large Telescope is equipped with adaptive optics working at a near-infrared wavelength of λ = 1600nm. Would it be able to resolve your asteroid when it is at its minimum distance to Earth. (15 points)

5. Imagine an ESA mission has landed a rover on your asteroid. The travel time for light will have a significant impact on communications with the robotic explorer. How much time will pass before a command sent from Earth has reached the rover? Assume the asteroid is at its minimum distance from the Earth. (6 marks)

6. Water ice sublimates (goes from solid → gas) when the surface temperature T is ≥ 200 K and carbon dioxide sublimates when T ≥ 85K. Could either of these ices survive at the equator of your asteroid? (15 points)

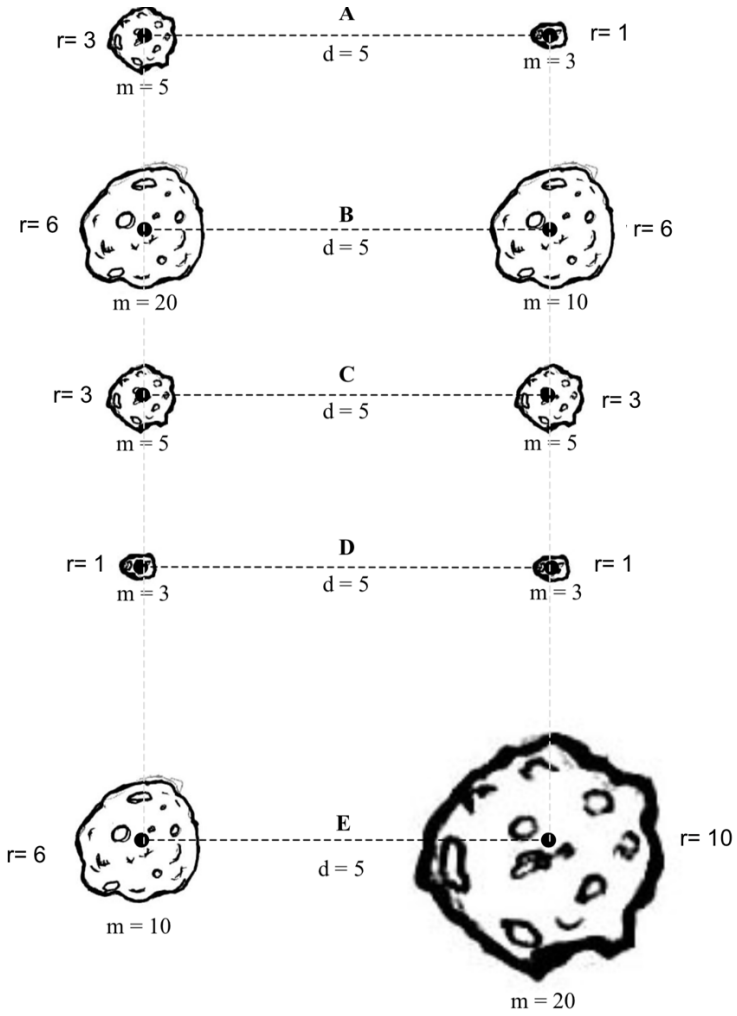
7. The V -band photon luminosity of the Sun is approximately 1.2×10^{45} photons/second. For the closest possible distance of your asteroid from question 4, calculate the apparent V -band magnitude of your asteroid. (15 points)

Asteroids:

Designation	Name	Rough D (km)	Albedo	a (au)	e
40	Harmonia	107.6	0.15	2.267	0.047
41	Daphne	174	0.04	2.765	0.272
42	Isis	100.2	0.16	2.442	0.223
43	Ariadne	65.9	0.13	2.203	0.168
44	Nysa	70.6	0.48	2.423	0.149
45	Eugenia	214.6	0.03	2.722	0.083
46	Hestia	124.1	0.04	2.527	0.172
47	Aglaja	127	0.04	2.879	0.135
48	Doris	221.8	0.06	3.108	0.075
49	Pales	149.8	0.06	3.086	0.234

Gravity (12 points)

8. Use the following diagram in the questions below, where m= asteroid mass, r= asteroid radius, and d=distance between the centers of the two asteroids:



(a) Ranking Instructions: Rank (from least to greatest, noting which cases if any have the same values) the strength of the gravitational force exerted on the asteroid located on the right side of each pair. Carefully explain your reasoning (in 4 sentences or less) for your ranking. (6 points)

(b) Ranking Instructions: Rank (from greatest to least, noting which cases if any have the same values)) the strength of the gravitational force exerted on the asteroid located on the left side of each pair. Carefully explain your reasoning (in 4 sentences or less) for your ranking. (6 points)