1) The average outward heat flux due to tidal flexing from the surface of Io is $F_{\text{tid}} = 2.25 \text{ W/m}^2$. It is caused by the eccentricity of the satellite’s orbit around Jupiter by moons such as Europa and Ganymede, and by the viscous dissipation of tidal flexing of Io’s body.

a) Compare that flux with the insolation (flux of solar irradiation) recalculated as the average flux spread over the whole surface of Io (not just its sun-lit side). Assume that 63% of incoming solar radiation is scattered and 37% absorbed.

b) Draw conclusions as to what is heating Io more: tidal interaction with Jupiter or the irradiation by the sun.

c) If its surface cools down according to the Stefan-Boltzmann law, and summing up the tidal and radiative (absorbed) fluxes, what is the expected mean temperature $T$ of Io’s surface?

2) Show that the Bond albedo of a Lambertian surface is $1.5A_0$ (i.e. 1.5 times its geometric albedo).

3) Problem 3.26 (a, b, c, and d) from the second edition of *Planetary Sciences* (de Pater & Lissauer).

4) **Essay question. (For PHYS 480 students, this is an optional/bonus question.)** Consider the greenhouse effect and the runaway greenhouse effect in planetary atmospheres. The runaway greenhouse effect occurred on Venus. Is it also occurring on Earth? Will it soon? Will it ever? How does it compare to Venus? Support your answers to these questions primarily with facts, though there is some room for your personal views in this essay as well (since there is still a lot of uncertainty regarding the future of Earth's climate). However, be sure to clearly state any assumptions you make, especially when presenting your views.

Write 1-2 pages (Times fontsize 11, 1 inch margins). Cite references (i.e. published papers) if you use any.