Homework # 1

Due before Tuesday, September 22nd

README: Make sure you write down all steps to solve the problems, so that I can give partial credit if needed. If I do not see the procedure you followed to solve the problem, you will get a zero on that problem. Also, be careful with units: they are extremely important! Only use the constants and values provided to solve the problems. Finally, make sure you write neatly so that I can understand it: if I don't understand what you wrote, you will get a zero. Scan the solution (into a single PDF, preferably) and send it back to me before the deadline. When a comparison between quantities is asked for, you need to calculate the ratio between the two quantities. When asked to make a figure/plot/diagram, make sure you produce this figure electronically, either with python coding (preferably) or with Excel (or similar).

CONSTANTS and OTHER VALUES (only use the provided constants/values to solve the problems):

$G = 6.673 \times 10^{-11}$ N m^2 / Kg^2
1 day = 86400 sec
1 year = 3.1536×10^7 sec

$M_{Jupiter} = 1.8986 \times 10^{27}$ kg	$R_{Jupiter} = 7.149 \times 10^7$ m
$M_{Sun} = 1.9891 \times 10^{30}$ kg	1 AU = 1.4959787×10^{11} m
$M_{Earth} = 5.9736 \times 10^{24}$ kg	$R_{Earth} = 6.378136 \times 10^6$ m

$P_{Io} = 1.769$ days	$a_{Io} = 421.6 \times 10^3$ km
$P_{Callisto} = 3.551$ days	$a_{Callisto} = 670.9 \times 10^3$ km
$P_{Ganymede} = 7.155$ days	$a_{Ganymede} = 1070.4 \times 10^3$ km
$P_{Europa} = 16.689$ days	$a_{Europa} = 1882.7 \times 10^3$ km

1. The Hubble Space Telescope is in a nearly circular orbit, approximately 610 km above the surface of Earth. Estimate its orbital period (in minutes).

2. Communication and weather satellites are often placed on geosynchronous orbits above Earth. These are orbits where satellites can remain fixed above a specific point on the surface of Earth. At what altitude must these satellites be located (in units of km and Earth radius)?

3. Using the data provided above for Jupiter, calculate the escape speed at the surface of Jupiter in km/s. Compare this value to the escape speed from Earth surface.

4. Calculate the escape speed (in km/s) from the Solar System, starting from Earth's orbit (assume that the Sun contain all of the mass of the Solar System); compare this value to the escape speed from Earth surface.

5. Cometary orbits usually have very large eccentricities, often approaching (or even exceeding) unity). Halley's comet has an orbital period of 76 years, and an orbital eccentricity of e=0.9673. Calculate i) the semi-major axis (in AU) of the orbit of Comet Halley; ii) the mass of the Sun (in kg) using the orbital data of Comet Halley; iii) the distances (in AU) of Comet Halley from the Sun at perihelion and aphelion; iv) the orbital speeds (in km/s) of the comet when at perihelion and at aphelion; v) the ratio between these two orbital speeds; and vi) the ratio between the kinetic energy of Halley's comet at perihelion and its kinetic energy at aphelion.

6. The four moons (Io, Europa, Ganymede, and Callisto) that Galileo Galilei discovered orbiting Jupiter also follow the revisited Kepler's third law. Using the orbital period (P) and semi-major axis (a) of these four moons provided above, i) create a graph of y=(log10P) versus x=(log10a) (with Excel or any other plotting tools - not by hand); ii) show, from the graph, that the slope of the best-fit straight line through the data is equal to 3/2=1.5; iii) calculate the mass of Jupiter (in kg) from the value of the y-intercept (make the assumption that the mass of the four moons are negligible compared to the mass of Jupiter). How does this estimate compares to the actual mass of Jupiter (see constants above).