

Physics 331 Problem 3 — due Oct. 21, 2004

Gravitational force law

In the first problem you were asked to calculate the distance between the planets Earth and Mars on a given day d of year 2000

$$\text{distance} = |\mathbf{x}_m(d) - \mathbf{x}_e(d)| \quad ,$$

where \mathbf{x}_m and \mathbf{x}_e are two-dimensional vectors giving the locations of Mars and the Earth. In preparation for a calculation of orbital trajectories we will now calculate the force due to the combined gravitational pulls of the Earth, Mars and the Sun. The acceleration at a point \mathbf{x} is

$$\mathbf{A}(\mathbf{x}, d) = -GM_s \frac{\mathbf{x}}{|\mathbf{x}|^3} + GM_e \frac{\mathbf{x}_e(d) - \mathbf{x}}{|\mathbf{x}_e(d) - \mathbf{x}|^3} + GM_m \frac{\mathbf{x}_m(d) - \mathbf{x}}{|\mathbf{x}_m(d) - \mathbf{x}|^3} \quad ,$$

where $G = 6.67 \times 10^{-11} \text{ m}^3 \text{ sec}^{-2} \text{ kg}^{-1}$ and M_i is the Mass of object i . **When calculating orbits for Mars-bound space-craft please be sure to use consistent units!**

Sun	$1.99 \times 10^{30} \text{ kg}$
Earth	$5.94 \times 10^{24} \text{ kg}$
Mars	$6.42 \times 10^{23} \text{ kg}$

The problem:

Write a program which takes as input arguments day d and a 2-component position vector \mathbf{x} , and returns as output value the acceleration vector \mathbf{A} . Use this function to compute the following accelerations.

- $d = 100$, $\mathbf{x} = [1.111, 1.001] \times 10^{11} \text{ m}$
- $d = 140$, $\mathbf{x} = [1.111, 1.001] \times 10^{11} \text{ m}$
- $d = 262$, $\mathbf{x} = [1.763, 1.443] \times 10^{11} \text{ m}$

Please e-mail the following to my address `kankel@solar.physics.montana.edu`:

- The acceleration \mathbf{A} for each case above.
- A copy of the program you wrote.
- A copy of the command(s) used to run your program.