Physics UN2801 | Professor Christ
due 10/06/2022

Assignment #4

Reading:

Oct 4 Kleppner and Kolenkow 6.5

Oct 6 Kleppner and Kolenkow 3.7, 6.2, 6.3, 11.1, 11.2

Problems:

27. Kleppner and Kolenkow 5.3

28. Kleppner and Kolenkow 5.4

29. Kleppner and Kolenkow 5.6

30. Kleppner and Kolenkow 5.15

31. Kleppner and Kolenkow 5.19 (Note "mechanical energy" means kinetic and potential.)

32. (Kleppner and Kolenkow 1st edition) Find the forces implied by the following potential energies:

    (a) $U = Ax^2 + By^2 + Cz^2$

    (b) $U = A\ln(x^2 + y^2 + z^2)$ ($\ln = \log_e$)

    (c) $U = A\cos(\theta)/r^2$ (Here r, θ are plane polar coordinates.)

33. Consider the effect of a radio wave on an ionospheric electron discussed in Example 1.11 in Kleppner and Kolenkow. Use CGS units. To avoid unnecessary complications assume that the quantity $eE_0/m = 1$ cm/sec^2 and that the frequency of the radio wave is $\omega = 3$/sec.

    (a) If the electron is at rest at $t = 0$ evaluate the explicit solution to determine how far the electron has moved from its position at the time $t = 2\pi$ sec.

    (b) Using Python integrate Newton's equation using the simple Euler method of updating the position and velocity from their values at the time $t = n\Delta t$ to the time $t = (n+1)\Delta t$ using the velocity and acceleration at the time $t = n\Delta t$ described in class. If a time step $\Delta t = 0.1$ is used, how large a numerical error appears in the solution at the time $t = 2\pi$ sec? (Simply compare the exact and numerical solutions at $t = 2\pi$ sec.) Show a graph of your Python solution for the time interval 0 to 10 sec.

    (c) Show using Python that the "kick" given the electron when the electric field is turned on at t=0 can be reduced if the oscillating field is turned on slowly starting at $t = -8$ sec using:

$$E(t) = \frac{m}{e} \cdot \frac{1\,\mathrm{cm}}{\mathrm{sec}^2} \begin{cases} 0 & t \le -8 \text{ sec} \\ \frac{10^{0.5t/\mathrm{sec}}}{0.01+10^{0.5t/\mathrm{sec}}} \sin(\omega t) & -8 \text{ sec} \le t \le 0 \\ \sin(\omega t) & 0 \le t \end{cases} .$$

    [Note: This problem continues on a second sheet.]

Do this by comparing the electron's position at $t = 2\pi$ sec found for the original problem with the electron's position at $t = 2\pi$ sec for this second choice of $E(t)$ assuming that for this 2^{nd} case x and dx/dt vanish at $t = -8$ sec. Show a graph of your Python solution for the time interval -8 to 10 sec.

The necessary Python code might be developed by modifying the Juypter notebook: http://www.columbia.edu/ nhc1/UN2801/Python/ProjectileMotion.ipynb discussed in class or the sample Euler integration code that appears in the later example: http://www.columbia.edu/ nhc1/UN2801/Python/Leapfrog.ipynb.