Computational Physics

Assignment 1

Due date: 3rd April

1. Take the rigid pendulum,

$$\frac{d^2\theta}{dt^2} \;=\; -\sin\,\theta \;-\; \alpha\,\frac{d\theta}{dt} \;+\; A\,\cos\,\omega t\,.$$

a) Explore the phase diagram for the non-driven system, A=0. Take α = 0.5 and $\omega \;=\; \frac{2}{3}$. Start from the initial position

$$\theta(0), v(0) \;=\; \frac{d\theta}{dt}(0) \;\equiv\; (1.1, -0.1)\,.$$

b) Now introduce the drive, and vary its strength: take A = 0.5, 0.9, 1.07 and 1.1. Do you see any qualitative difference in the phase trajectories?

c) Try a slightly different initial condition: $\theta(0), v(0) = (1.09, -0.1)$. How does this slight difference in θ at $t = 0$ evolve with time, for the cases with the different drives?

2. Say DRDO is testing a missile, and has asked for your help. The missile is to be launched from Thiruvananthapuram ($8°30'\,N,\; 77°\,E$), pointing directly towards the west, making an angle of 45° with the horizontal. Where do you expect it to land? (By "land" I mean *hit the surface of the earth*: it will, judiciously, hit the sea.) Take the length of a day to be 24 hr. Ignore air resistance. Assume an initial velocity of 8000 km/hr. (Assume it attains this velocity at $t = 0$, and there are no boosters.)

How would the results have changed if the launch was from a point in the north, say, at $30°\,N$? Do your calculations properly, or you may start a war!

Explore the dependence of the result on the launch angle (what if the launch angle was 30°? 60°?), and on the earth's rotation (what would have happened if the earth was not rotating? If it was rotating at double the angular velocity?).

3. A simple phenomenological model for confinement of quarks uses a linearly rising central potential,

$$V(r) \;=\; -\frac{\alpha}{r} \;+\; \sigma\, r$$

to describe a bound state of a quark and an antiquark. Here r is the distance between the particles.

Let us try to use this potential to find the spectrum of charmonia (mesons made of charm and anticharm). Take the following parameter set: charm mass = 1.32 GeV, string tension σ = 0.2025 GeV^2, and α = 0.471. Find the masses of the two lightest S-wave mesons (l=0) and the lightest p-wave meson (l=1).

How do your results compare with the experimental numbers (see Particle Data Group)?