PHYS 350: PRACTISE QUESTIONS for MID-TERM-(1)

(Oct. 26th, 2004)

This is a 'mock' mid-term- the actual mid-term will have the same format (ie, with 4 questions, of which you have to choose 3). You should allow 15 mins to answer each question- the total length of the real mid-term will be 45 mins.

In order to get the maximum advantage from these model questions you should first revise the material thoroughly (looking at the notes and at the previous questions sheets), and then do the questions- making sure to time yourself.

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(1) A pendulum of length 10 m is hanging vertically without motion. At $t = 0$ we hit the pendulum, and it instantaneously acquires an angular velocity about its upper end of 0.1 rads/sec. Ignoring dissipation, what will be its maximum angular displacement (assuming $g = 10ms^{-2}$)?

(2) Explain the principle of least action for a system having a Lagrangian function $L(Q, \dot{Q}; t)$; this explanation should be brief. Now show how one can derive Lagrange's equations, viz.,

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{Q}}\right) - \frac{\partial L}{\partial Q} \; = \; 0 \tag{0.1}$$

starting from the principle of least action.

(3) A central potential that is often used in chemistry is the so-called "Morse potential", having the form

$$V(r) \; = \; \left(\frac{A}{r^{12}} - \frac{B}{r^6}\right) \tag{0.2}$$

(i) Find the effective potential in which the radial coordinate r of a particle in this potential will move.

(ii) If the particle comes in from infinity with zero energy and is aimed straight at the origin, what will be its closest distance of approach to the origin?

(4) two simple harmonic oscillators are made from equal masses $M = 1$, and springs with equal spring constants $k_o = 1$ (both in MKS units). We also couple them with a weak spring having a spring constant $k_1 = 10^{-3}$.

(i) Write down the Lagrangian and the equations of motion for the combined system.What are the dimensions of k_o and k_1?

(ii) What are the eigenfrequencies of the combined system?

(iii) What are the eigenfunctions?