KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
Physics Department

PHYS 301
Second Major Exam (2nd May, 2001) – Term 002

Instructor's Name: Dr. A. Mekki

Student's Name: _______________________________________

I.D. No: _________________________

Exam Time: 90 minutes
Show the details of your work and circle your answer

Problem #	**Grade**
1	/40
2	/30
3	/30
Total:	/100

Q1. (40 points)

Consider an RLC circuit connected in series to an alternating source $\varepsilon = \varepsilon_o \cos(\omega t)$ as shown in the figure. The switch is closed at t = 0.

(a) Show that the differential equation governing the charge in the capacitor is given by:

$$\ddot{q} + \frac{R}{L}\dot{q} + \frac{1}{LC}q = \left(\frac{\varepsilon_o}{L}\right)\cos\omega t \qquad (1)$$

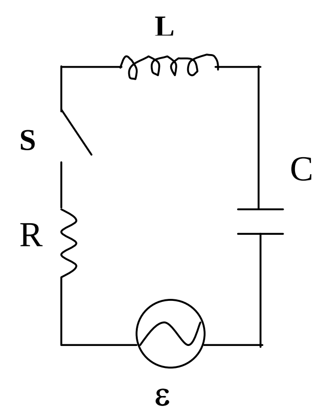
(b) Write the mechanical equivalent to the above equation and deduce the solution to equation (1) in the steady state mode in terms of R, L, C, ω and t.

(c) Find the voltage across the resistance as a function of time.

(d) What is the time averaged energy dissipated in the resistor?

(e) What is the time averaged energy stored in the capacitor?

(recall $\langle x \rangle = \frac{1}{T}\int_0^T x\,dt; \quad T = \frac{2\pi}{\omega}$)



Q2. (30 points)

Consider a non-uniform spherical mass distribution of density ρ (r) = Ar (A is a constant) and radius R. Calculate the gravitational field g (r) and potential ϕ (r):

(a) inside the sphere ($r < R$)

(b) outside the sphere ($r > R$)

(c) Draw few field lines and the corresponding equipotentials outside the sphere.

(d) What is the energy required to bring a point mass m from infinity to the surface of the sphere?

Q3. (30 points)

(a) Prove (in cartesian coordinates) that the curve that gives the shortest path between two fixed points $P_1(x_1, y_1)$ and $P_2(x_2, y_2)$ in the xy plane is given by a straight line that joins these two points.

(b) Consider two arbitrary points $P_1(a, Z_1, \phi_1)$ and P_2 (a, Z_2, ϕ_2) lying on the surface of a right cylinder of radius a.

(i) Use cylindrical coordinates to show that the path between the two points can be written in the form

$$s = \int_{\phi_1}^{\phi_2} \sqrt{a^2 + \dot{z}^2}\, d\phi$$

(ii) Show that in order to minimize the integral, the z coordinates should vary as

$z = A\,\phi$ where A is a constant

with the initial condition that $Z(\phi = 0) = 0$

(iii) Using the fact that in cylindrical coordinates, $x = a \cos \phi$ and $y = a \sin \phi$, what would be the shortest path between the points P_1 and P_2?