UNIVERSITY OF COLOMBO, SRI LANKA

FACULTY OF SCIENCE

FIRST YEAR EXAMINATION IN SCIENCE – SEMESTER II – 2007/2008

PH 1003– WAVES & VIBRATIONS AND CIRCUIT THEORY

(Two Hours)

Answer ALL (FOUR) questions

Electronic calculators are allowed.

(This question paper consists of 04 questions in 07 pages.)

Important Instructions to the Candidates

- If a page or a part of this question paper is not printed, please inform the supervisor immediately.
- Enter Your Index Number on all pages of the answer script.
- MCQ TYPE: In each of these multiple choice questions, encircle the number of the correct response.
- ESSAY TYPE: Write the answers to these questions on writing papers provided.
- Electronic devices capable of storing and retrieving text, including electronic dictionaries and mobile phones are not allowed.

  In this question paper, questions 1, 2 & 3 are essay type questions. Question 4 consists of 15 Multiple Choice Questions.
- At the end of the time allowed for this paper, attach question 4 with the marked responses to your written answers to questions 1, 2 and 3 (answer book) and hand them over to the supervisor or invigilator as one answer script. Please make sure that you handover both English and Sinhala versions of the question 4 to the supervisor or invigilator.
- You are permitted to remove only questions 1, 2 and 3 of the question paper from the Examination Hall.

1. (i) (a) Show that if the displacement of an object can be given by $x = A\sin(\omega t + \alpha)$, the object undergoes simple harmonic motion.

(b) (i) Discuss qualitatively how the speed, amplitude and period of oscillations of a simple harmonic oscillator vary with time in the presence of a light damping force which is proportional to the speed of the oscillator.
(ii) When the damping force is given by $F = -bv$ (where v is the speed of the oscillator) for a damped oscillator with mass m, show that the time constant for the time variation of energy of the oscillator is given by m/b. Assume that the damping is small.

(ii) (a) Derive an expression for the current i in a series L-R circuit connected across a DC battery of e.m.f. E at a time t after the battery is connected. Assume that the battery has no internal resistance.

(b) Sketch how the current i and the voltage across the resistor V_R vary with time in the L-R circuit described in ii (a).

2. (i) Consider two waves with equal frequencies, amplitudes and velocities traveling in *opposite* directions represented by $y_1 = A\sin(\omega t - kx)$ and $y_2 = A\sin(\omega t + kx)$

(a) By deriving the equation for the resultant wave, show that the superposition of the above two waves results in a standing wave.

(b) Find the distances, x at which nodes and antinodes occur in terms of wavelength, λ

(ii) A plane progressive mechanical wave is represented by the equation given below:

$$y = 0.1\sin\left(200\pi t - \frac{20\pi x}{17}\right)$$

where y is the displacement of a particle in millimetres, t is in seconds and x is the distance to the particle from a fixed origin in metres.
Find the
(a) wavelength,
(b) wave velocity,
(c) maximum value of the particle velocity, and
(d) maximum acceleration of a simple harmonic oscillator in the wave.

(iii) A radar machine used to monitor the speed of the vehicles emits microwaves with frequency f towards a car traveling at high speed approaching the radar machine. Show that the relationship between the shift in frequency of the microwaves Δf received by the radar machine after reflecting from the traveling car and the speed of the car v is given by $v = c\Delta f/2f$ where c is the speed of light. Assume that the speed of the car is negligible compared to the speed of light c

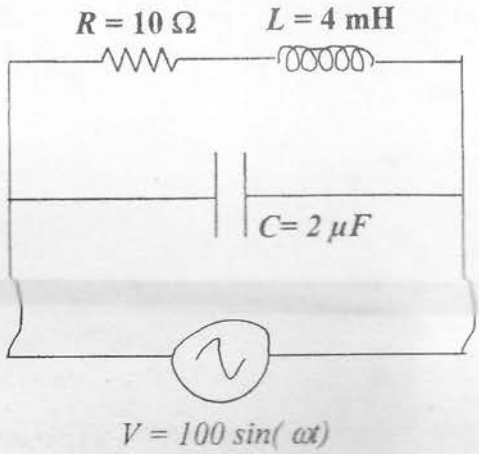
3. (i) Derive an expression for the resonant frequency f_o of the following circuit in terms of L, C and R.

At resonance, using the values given in the circuit, find the

(a) value of the of resonance frequency of the circuit.

(b) rms values of the currents through L and C.

(c) rms value of the total current drawn from the voltage supply.



(ii) A series LCR series circuit consists of L = 0.2 H, R = 10 Ω and a variable capacitor with capacitance C. Find the value of C to make the circuit resonant at the frequency of the voltage supply, $V = 150\sin 120\pi t$ connected across the series circuit.

At resonance, also find the

(a) rms value of the current.

(b) power factor.

(c) power dissipation in the circuit.

(d) quality factor of the circuit.