UNIVERSITY OF COLOMBO, SRI LANKA

FACULTY OF SCIENCE

FIRST YEAR EXAMINATION IN SCIENCE – SEMESTER II – 2008/2009

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 08 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) Show that an object undergoes simple harmonic motion if its displacement is given by $x = A\cos\omega t$. Draw the variation of its displacement, velocity and the acceleration of the object with time.

(ii) Sketch variation of displacement with time when a simple harmonic oscillator is subject to (a) light damping (under damping), (b) critical damping and (c)over damping.

(iii) When the switch in the circuit shown below is closed, find the

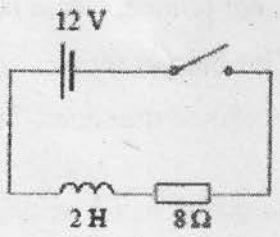
(a) initial current,

(b) initial rate of rise of current. Is this the maximum or minimum rate of current in the circuit ?

(c) final value of the current,

(d) final energy stored in the inductor.

(Ignore the internal resistance of the battery)



2. (i) (a) By considering two perpendicular oscillations, $x = A_1\sin(\omega t + \phi_1)$ and $y = A_2\sin(\omega t + \phi_2)$, show that their superimposition gives rise to a waveform characterised by a general equation of an ellipse.

(b) If $A_1 = A_2$, $\phi_1 = 0$ and $\phi_2 = \pi/2$, deduce the equation for the resultant wave form due to the superposition of the above two waves described in (i) (a) and indicate the special shape of this wave form.

(ii) (a)By obtaining the equation for the resultant wave form, show that the superposition of the two waves in the form of $y_1 = A\sin(\omega_1 t - k_1 x)$ and $y_2 = A\sin(\omega_2 t - k_2 x)$ give rise to an amplitude modulated wave.

(b) Sketch the resultant wave form of the amplitude modulated wave

(c) Obtain expressions for the corresponding group velocity and phase velocity.

3. (i) Show that the magnitude of the total impedance and the phase difference of a series L-C-R circuit can be given by $[R^2 + (\omega L - 1/\omega C)^2]^{1/2}$ and $\tan^{-1}[(\omega L - 1/\omega C)/R]$ respectively where all the symbols have their usual meaning.

(ii) A series *LCR* circuit has an inductance (L) of 0.5 H and a resistance (R) of 80 Ω and is connected across a 230 V (V_{rms}) sinusoidal supply. What is the value of capacitance (C) required for the circuit to be resonant at a frequency of 50 Hz.

Calculate the following at resonance:

(a) The current in the circuit

(b) The power factor of the circuit

(c) The voltage across L, C and R

(d) The quality factor (Q)

(e) The energy dissipated in the circuit in 05 minutes

(f) Draw a rough sketch to show how the impedance and the current vary with the frequency in the vicinity of resonance.

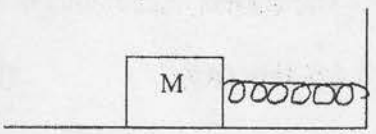
- Question 4 consists of 15 multiple choice questions.
- Encircle the number of the correct response on the question paper itself.
- Please note that there is **only one correct response** to each question.
- Enter your Index Number in all pages.
- **Please hand over both Sinhala and English versions of question 4 to the supervisor or invigilator along with the answer script of questions 1,2 &3.**

4.

(i) A particle undergoing simple harmonic motion has an amplitude A and maximum acceleration a_o . The magnitude of its acceleration at half amplitude (i.e. at A/2) will be:

(a) $a_o/4$ (b) $a_o/2$ (c) $a_o/\sqrt{2}$ (d) $(\sqrt{3}\, a_o)/2$ (e) a_o

(ii) A metal block M, attached to one end of a light spring is set into vibration in air on a smooth horizontal plane as shown in the figure. Then it will most probably undergo



(a)Damped vibrations
(b) Undamped simple harmonic motion
(c) Forced vibrations
(d) Critically damped motion
(e) Over damped motion

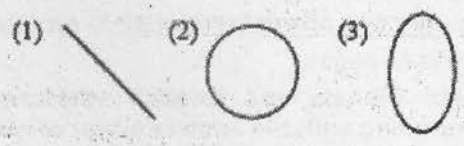
(iii) Consider the wave equation $\partial^2 y/\partial x^2 = (1/2\pi)\partial^2 y/\partial t^2$
The square of the speed of the wave is

(a) 2π units (b) $1/2\pi$ units (c) $\sqrt{2}\pi$ units (d) $4\pi^2$ units (e) π units

(iv) Two loudspeakers are connected to the same signal generator. At a point equidistant from the two loudspeakers, a maximum intensity of intensity level 60 dB is detected. If one loudspeaker is disconnected, the intensity level at that point will be

(a) 57 dB (b) 54 dB (c) 46 dB (d) 30 dB (e) 15 dB

(v) Two sinusoidal a.c. signals having a phase difference of 90° are applied to the *x*-plates and *y*-plates of a CRO. Which of the following traces may appear on the screen of the CRO depending on their frequencies?



(a) (1) only
(b) (3) only
(c) (1) and (2) only
(d) (2) and (3) only
(e) (1), (2) and (3)

(vi) Consider the following three statements about sound waves

(A) Non-periodic signals may be considered as noise
(B) Music can be synthesized using Fourier theorem.
(C) Complex periodic sound signals can be analysed using Fourier theorem.

The correct statement/s is/are

(a) only (A) (b) only (B) (c) only (A) & (B)

(d) only (A) & (C) (e) all

(vii) Which form of the following equations represent a traveling wave?

(a) $y = 10\sin(x - 2t)$
(b) $y = 10\sin(x^2 t)$
(c) $y = 10\log(2t)$
(d) $y = 10\cos^2(x^2 - 2t^2)$
(e) $y = 10\sin(\omega t + \varphi)$

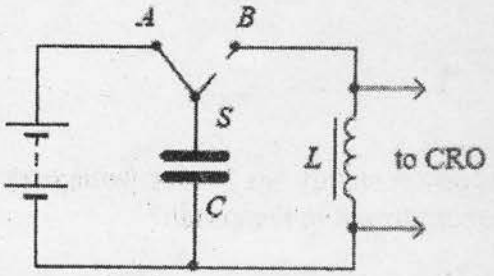
(viii) Which form of the following equations represents a standing wave (or stationary wave) ?

(a) $y = 20\sin(\omega t + \pi/3)$
(b) $y = 20\sin kx \sin(\omega t - \pi/6)$
(c) $y = 20e^{-bx}\sin(\omega t - kx + \pi/4)$
(d) $y = 20\sin(\omega t + 0.2)$
(e) $y = 20\cos kx \sin\omega t$

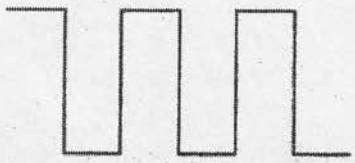
(ix) A 1 μF capacitor, which is initially charged, is discharged through a 50 Ω resistor. The maximum current during discharge is 100 A. What is the initial charge on the capacitor?

(a) 5×10^{-3} C (b) 1×10^{-4}C (c) 5×10^{-4} C (d) 1×10^{3} C (e) 5×10^{3} C

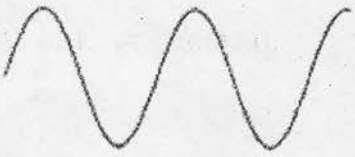
(x) A capacitor C and an inductor L with some resistance are connected to a battery as shown in figure. When switch S is moved from A to B, what could be the trace appeared on the screen of the CRO varying with time (i.e the trace of the voltage across L varying with time).? (Assume that L is a real inductor having a small resistance).



(a)

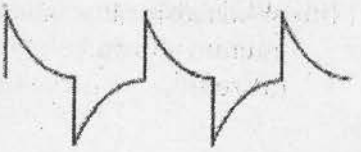


(b)



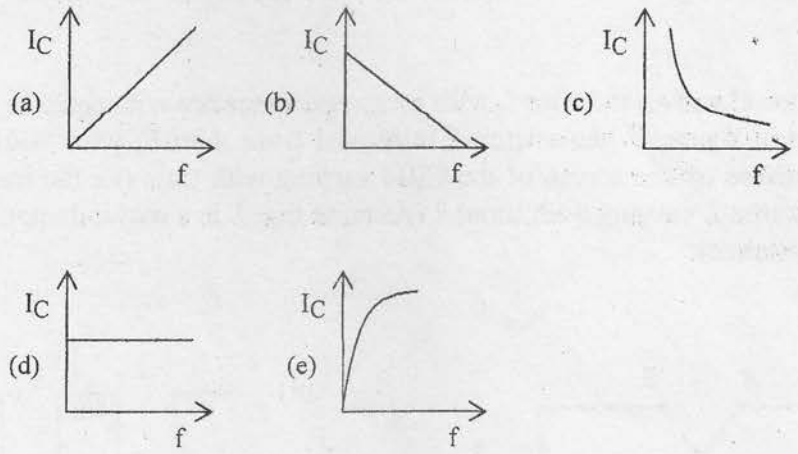
(c)

(d)



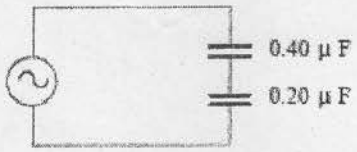
(e)

(xi) Select the graph which shows the correct variation of the current through a capacitor I_C in an ac circuit having a power supply with frequency f.



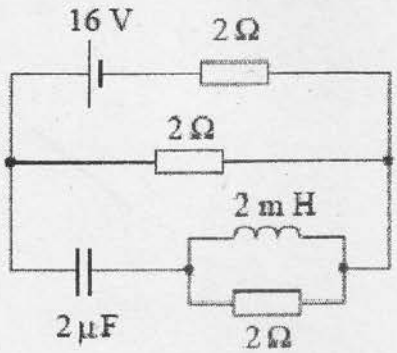
(xii) In the circuit shown below, the a.c. power supply has a r.m.s. voltage of 5.0 V alternating at 50 Hz. What is the r.m.s. current in the circuit?

(a) 0.033 A (b) 0.12 A (c) 0.21mA (d) 120 mA (e) 210 mA



(xiii) When a steady state is reached, the current delivered by the battery in the circuit shown below is

(a) zero. (b) 4.0 A. (c) 5.0 A. (d) 5.3 A. (e) 8.0 A.



(xiv) In a series L-R circuit, as the frequency increases, the impedance of the circuit
(a) decreases
(b) increases
(c) remains unchanged
(d) first increase and then decreases
(e) first deceases and then increases.

(xv) In a LCR series circuit, the magnitude of the voltage across inductance (L) and capacitance (C) is same and it is equal to 40 V. If the resistance (R) is 10 Ω and the applied voltage cross the series combination is 100 V (Vrms), the rms value of the current in the circuit will be
(a) 4 A (b) 6 A (c) 10 A (d) 0 A (e) infinite.

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