UNIVERSITY OF COLOMBO, SRI LANKA

FACULTY OF SCIENCE

FIRST YEAR EXAMINATION IN SCIENCE – SEMESTER II – 2003/2004

PH 1003– WAVES & VIBRATIONS AND AC THEORY

(Two Hours)

Answer ALL (FOUR) questions

Electronic calculators are allowed.

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

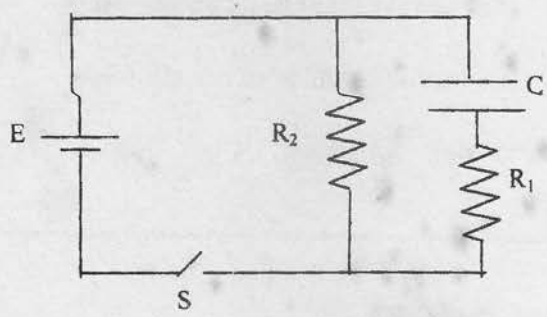
Important Instructions to the Candidates

- 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 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. (a) Show that a simple harmonic motion (SHM) can be represented by the equation $d^2x/dt^2 = -\omega^2 x$ where all the symbols have their usual meaning. When the amplitude is A, obtain an expression for the velocity at the displacement of x.

   (b) Sketch how the amplitude varies with time when a SHM is subject to light damping (under damping)

   (c) In the circuit shown below, the switch S is closed at time t = 0. (Assume that the battery has no internal resistance and the capacitor is originally uncharged)



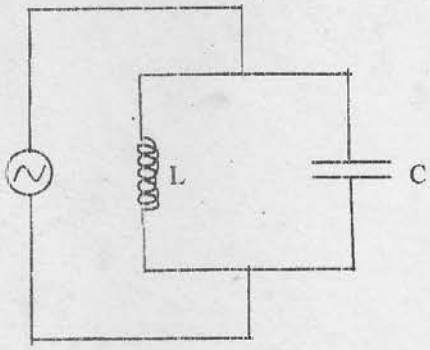
   (i) What is the current supplied by the battery just after the switch is closed (i.e at t = 0).
   (ii) What is the current supplied by the battery long time after the switch is closed?
   (iii) After long time, if the switch is open what will be the current in the circuit after 0.01 s from the time of opening the switch when E = 10 V, R_1 = 10 kΩ, R_2 = 2 kΩ and C = 2 μF. Assume that the battery has no internal resistance.

2. (a) A loudspeaker at a musical show generates sound of 25 W. Assume that it spreads its total energy uniformly only in the forward hemisphere.

   (i) What is the sound intensity level (in dB) at 25 m from the loudspeaker? (The sound intensity corresponding to the threshold of hearing is 10^{-12} Wm^{-2})
   (ii) If five such loudspeakers are in operation together at the same place, what would be the increase in sound intensity level (in dB) at 25 m from the speakers.
   (iii) At what distance will the sound intensity be at the pain of threshold (i.e. 120 dB) when all the five loudspeakers are in operation.

(b) A whistle emitting sound of frequency of 600 Hz moves in a circle of radius 1.5 m at 4 revolutions per second. What are the minimum and maximum frequencies heard by a listener moving towards the whistle at a speed of 60 ms^{-1} starting from a distant point. Assume that the speed of sound in air = 340 ms^{-1}.

3. (a) Derive expressions for the current in an ideal inductance and ideal capacitance, when the voltage applied across each of them is in the form of $V = V_0 \sin\omega t$.



In the circuit shown above, the peak value of the current (I_0) through the inductor is 1.0 A and that through the capacitance is 0.8 A.

(i) What is the rms value of the total current drawn from the power supply.
(ii) What is the power factor in the circuit
(iii) What is the power dissipation in the circuit

(b) In a LCR series circuit, L = 0.1 H, R = 20 Ω and C is a variable capacitor. This circuit is connected across a sinusoidal voltage supply given in the form of $V = 200\sin 100\pi t$. Find the value of C to make the circuit resonant at the frequency of the voltage supply. Then, find the rms value of the current and the power dissipation in the circuit at resonance.

- Question 4 consists of 15 multiple choice questions.
- In each of these questions, encircle the number of the correct response on the question paper itself.
- Enter your Index Number in all pages.

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4. (i) A particle undergoing simple harmonic motion has an amplitude A and maximum velocity V_m. Its velocity at half amplitude (i.e. at A/2) will be

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

(ii) The vibrations in the diaphragm of a microphone are

(a) Free vibrations (undamped)
(b) Damped vibrations
(c) Electrically maintained vibrations
(d) Forced vibrations
(e) None of the above.

(iii) Which of the following represents a traveling wave?
(All the symbols have their usual meaning)

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

(iv) The equation of a transverse wave is given by $y = 20\sin\pi(0.02x - 4t)$ where x and y are in m and t in s. The frequency of this wave is

(a) 0.01 Hz (b) 0.02 Hz (c) 2 Hz (d) 4 Hz (e) 8 Hz.

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(v) The intensity level of sound X is 30 dB greater than that of Y. How many times more intense is the sound X than Y?

(a) 3 (b) 30 (c) 300 (d) 100 (e) 1000

(vi) Which of the following represents a standing wave (or stationary wave) (All the symbols have their usual meaning)

(a) $y = A\sin(\omega t + \alpha)$
(b) $y = A\sin kx\sin(\omega t - \varphi)$
(c) $y = Ae^{-bx}\sin(\omega t - kx + \varphi)$
(d) $y = A\sin(\omega t + kx)$
(e) $y = A\cos kx\sin(\omega t - kx)$

(vii) The linear density of a vibrating string is 1.5×10^{-4} kgm^{-1}. A transverse wave in the form of $y = 0.021\sin(x + 20t)$ is propagating along the string where x and y are measured in m and t in s. The tension of the string is

(a) 0.06 N (b) 1.20 N (c) 0.48 N (d) 4.80 N (e) 0.96 N

(viii) Consider the three statements given below about the Fourier's theorem.

(A) It can be used to analyse any periodic wave in terms of sinusoidal functions
(B) It can be used to identify the components of the waveforms of sound produced by different musical instruments.
(C) It can not be used to find the components of a square waveform.

The correct statement/s is/are

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

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

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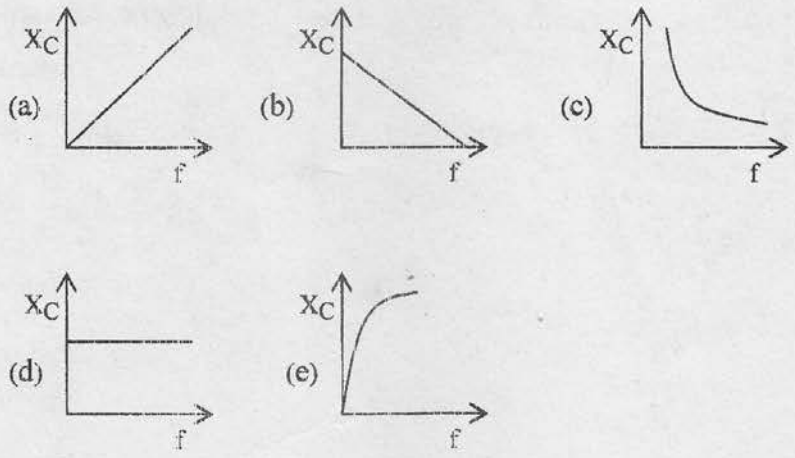
(ix) An inductor of 2 H and a resistance of 20 Ω are connected in series in a circuit containing a dc source of 50 V. The time constant of the circuit is

(a) 40 s (b)10 s (c) 20 s (d) 0.1 s (e) 25 s

(x) A fully charged capacitor is being discharged through an inductor of 0.01 H. The initial current through the inductor increases from 0 A to 2 A in 2μs. The instantaneous voltage across the inductor is

(a) 20 kV (b) 10 kV (c) 5 kV (d) 1 kV (e) 100 kV

(xi) What is the graph which shows the correct variation of the reactance of a capacitor X_C in an ac circuit with the frequency f of the source voltage?



(xii) An ideal inductance of 10.0 mH is connected across an voltage supply given in the form of V = 20sin(200t). The peak current in the circuit will be

(a) 2 A (b) 5 A (c) 10 A (d) 20 A (e) 30 A

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(xiii) In a series C-R circuit, as the frequency increases, the impedance of the circuit

(a) decreases
(b) increases
(c) remains unchanged
(d) first increases and then decreases
(e) first deceases and then increases

(xiv) When a dc supply of 200 V is applied across a real coil, a steady current of 2 A flows through it. When an ac supply of V_{rms} = 200 V, 50 Hz is applied across the same coil, the rms value of the current through it is 1 A. The inductance of the coil is approximately

(a) 1.0 H (b) 0.85 H (c) 1.1 H (d) 0.92 H (e) 0.55 H

(xv) In a LCR series circuit, the magnitude of the voltage across each resistance, inductance and capacitance is same and it is equal to 20 V. If the resistance ($R = 4\ \Omega$) is short circuited, the current in the circuit will be

(a) 5 A (b) 10 A (c) 15 A (d) infinite (e) data given is not enough

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