UNIVERSITY OF COLOMBO, SRI LANKA

FACULTY OF SCIENCE

FIRST YEAR EXAMINATION IN SCIENCE – SEMESTER II – 2004/2005

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.(a) (i) Write the properties of simple harmonic motion.

(ii) Sketch how kinetic energy, potential energy and total energy of simple harmonic oscillator vary with the displacement (x) from –A to +A where A is the amplitude of the motion.

(iii) A small mass of 10 g undergoes simple harmonic motion with an amplitude of 10 cm. Its total energy is 1 J. Find the magnitude of the velocity of the mass at a displacement of 2 cm.

If the mass is at -10 cm at time $t = 0$, write an expression for displacement (x) at time t.

What would be the effect of the presence of a damping force on the velocity and frequency of oscillations in the above motion ? (Explain qualitatively).

(b) The displacement (y) of a mechanical wave on a stretched string is given in the form of $y = 10\sin 2\pi[t/0.04 - x/50]$ where x and y are in centimeters and t in seconds.
Find the

(i) direction of propagation ($+x$ or $-x$ direction) of the wave

(ii) period of the wave

(iii) wave vector (k) in rad m^{-1}

(iv) velocity of the wave in m s^{-1}

(v) maximum velocity of the particles in the string in m s^{-1}

(vi) equation of the reflected wave (y_r) when the above wave is perfectly reflected at a hard boundary. Justify your answer.

2. (a) A small sound source emits sound uniformly in all directions. The sound intensity level at a distance of 3 m from the source is 120 dB. The sound intensity corresponding to the threshold of hearing is 1.0×10^{-12} W/m^2.

(i) What is the power of the sound source?

(ii) How do your answer in (i) supports the fact that even highly intense sound sources emit only little power

(iii)If the power of the sound source is reduced to half of its original value, what would be the sound level in dB at 3 m from the source. Comment on your answer.

(b) A series LCR circuit consisting of L = 0.1 H, C = 20 μF and R = 50 Ω is connected across 240 V, 50 Hz power supply.

Find the

(i) current in the circuit

(ii) power factor

(iii) power dissipation and

(iv) also find whether the circuit is inductive, capactive or resistive. Give reasons to your answer

If you want to make the above circuit resonate at 50 Hz, what is the new capacitance which should be added to the circuit? How do you connect it in the circuit; in series or in parallel?

3. A capacitor (C) of 400 μF charged to 200 μC is connected across an inductor (L) of 40 mH so that LC oscillations occur. Assume that there is no resistance associated with L or C.

(a) Show that the charge (q) in the capacitor oscillates in a simple harmonic motion and obtain an expression for the charge (q) at time t.

(b) Find the frequency of LC oscillations.

(c) Obtain an expression for the current at time t.

(d) Find the current just after the inductor is connected (i.e. at $t = 0$)

(e) What is the maximum current in the circuit?

(f) Sketch how charge and current vary with time, on the same time axis.

(g) What is the phase difference between the charge and the current ? Which is leading; current or charge ?

(h) If L has with a small resistance, sketch how the current vary with time.

- 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.**

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4. (i) Consider the following three statements about simple harmonic motion of a body in the absence of any dissipative force

(A) It vibratès under the action of a linear restoring force with a single natural frequency.
(B) Its period of motion is independent of amplitude.
(C) The amplitude of vibration decreases with time.

Of the above statements,
(a) only (A) is correct
(b) only (A) and (B) are correct
(c) only (B) and (C) are correct
(d) only (A) and (C) are correct
(e) all are correct

(ii) The best condition for an automobile shock absorber may be

(a) slightly under damped vibrations
(b) free vibrations (undamped)
(c) over damped vibrations
(d) critically damped vibrations
(e) none of the above.

(iii) Consider the wave equation $d^2y/dt^2 = (1/10)d^2y/dx^2$
The velocity of the wave is

(a) 10 units (b) 100 units (c) $1/\sqrt{10}$ units (d) $\sqrt{10}$ units (e) 0.1 units

(iv) The wave equation, $y = 2A\cos(2\pi x/\lambda)\sin(2\pi vt/\lambda)$, where all the symbols have their usual meaning, represents a

(a) simple harmonic motion without damping
(b) simple harmonic motion with damping
(c) damped forced vibration
(d) progressive wave
(e) standing wave

(v) If a certain sound intensity is increased by 100 times, then, the sound intensity level is increased by

(a) 2 dB (b) 10dB (c) 20 dB (d) 100 dB (e) 1000 dB

(vi) A transverse wave given by $y = 0.02\sin(2x+35t)$ is propagating on a string having a linear density of 1.5×10^{-4} kg m^{-1} where x, y are given in meters and t in seconds. The tension of the string is (approximately)

(a) 0.05 N (b) 0.1 N (c) 0.5 N (d) 1 N (e) 5 N

(vii) Consider the three statements given below about sound waves

(A) Non-periodic sound may be heard as noise.
(B) Sound from a musical instrument may consists of several harmonics
(C) Fourier theorem is applicable to both periodic and non-periodic sounds.

The correct statement/s is/are

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

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

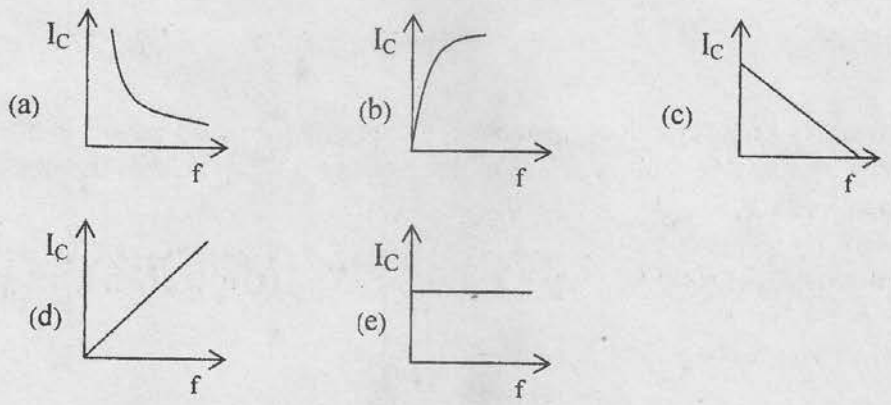
(viii) Out of the following, what is the false statement about a Tsunami

(a) Wave length of a Tsunami can be more than one hundred kilo meters.
(b) It is different from a normal wind driven water wave in several respects
(c) When a Tsunami approaches shallow water, its wave length increases.
(d) When a Tsunami approaches shallow water, its speed decreases.
(e) It looses negligible energy in deep sea.

(ix) The average value of the main power supply in Sri Lanka over a half cycle is approximately (Assume that V_{rms} of the power supply = 230 V)

(a) 230 V (b) 207 V (c) 361V (d) 163 V (e) 325 V

(x) Select the graph which shows the correct variation of the current through a capacitor (I_C) in an ac circuit with the frequency (f) of the source voltage.



(xi) When charging a capacitor (C), through a resistor (R) connected in series with the capacitor, the charge on the capacitor after 5 time constants will be approximately (in terms of maximum charge q_o)

(a) $q_o e^{-5}$ (b) q_o/e^{-5} (c) $\sqrt{5}q_o$ (d) $q_o/\sqrt{5}$ (e) q_o

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(xii) When the frequency of the power supply connected to a series L-R circuit increases, the current in the circuit

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

(xiii) Let the output across R and C of a series CR circuit be V_R and V_C respectively and input signal be V_i. Select the condition under which the CR circuit acts as an integrating circuit.

(a) When $V_i >> V_R$
(b) When $V_i << V_R$
(c) When $V_i = V_C = V_R$
(d) When $V_i >> V_C$
(e) When $V_i << V_C$

(xiv) In a series LCR circuit at resonance, the quality factor (Q factor) is 50. If the supply voltage is 100 V (V_{rms}), the voltage (V_{rms}) across the resistor at resonance is

(a)100 V (b) 5000 V (c) 2 V (d) 50 V (e) data given is not enough

(xv) In a parallel LCR circuit at resonance, if R = 50 Ω, L = 0.1 H, C = 40 μF, then, the correct statement about the circuit at resonance is

(a) The resonance frequency is 1500 Hz
(b) Power factor is 0
(c) Total current is maximum
(d) Total impedance is minimum
(e) The total admittance is 1/50 Ω^{-1}

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