UNIVERSITY OF COLOMBO, SRI LANKA

FACULTY OF SCIENCE

FIRST YEAR EXAMINATION IN SCIENCE – SEMESTER II – 2006/2007

PH 1003– WAVES & VIBRATIONS AND CIRCUIT THEORY

(Two Hours)

Answer ALL FOUR questions

Electronic calculators are allowed.

(This question paper consists of 04 questions on 08 pages.)

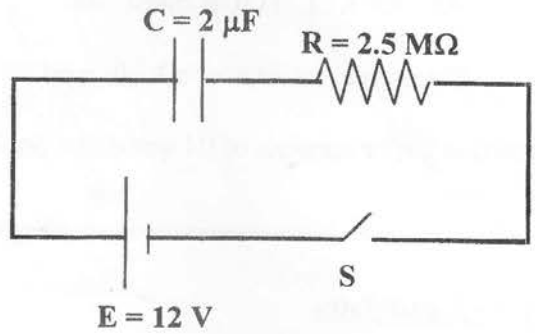
Important Instructions to the Candidates

- 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. (a) The displacement (x) of a particle is represented by $x = A\ sin(\omega t + \varphi)$. Show that the particle is undergoing simple harmonic motion (SHM) where all the symbols have their usual meaning.
   (i) Obtain an expression for the velocity at the displacement x.
   (ii) If the displacement of the above particle (in centimeters) at time t (in seconds) is given by
   $x = 5.2sin(0.5\pi t + \pi/3)$, find the period, maximum velocity and the maximum acceleration of the particle.

   (b) If the particle in (a) experiences a slight damping force and a periodic force in the form of $F = F_o cos\omega' t$ simultaneously, sketch how the amplitude varies with time. Give reasons in brief for the shape of the sketch you have drawn.

   (c) The switch S in the circuit shown below is closed at time $t = 0$. Assume that the capacitor has no charge at $t = 0$ and the battery has no internal resistance.



   (i) Derive an expression for the charge in the capacitor at time t and find the charge stored in the capacitor after one time constant.

   (ii) Find the approximate value of current in the circuit after 10 time constants.

   (iii)Find the maximum charge which can be stored in the capacitor?

2. (a) A transverse wave traveling on a string is represented by
   $y\ (x,t) = 10.5\ sin\ (16t - 0.04x + \pi/6)$ where x and y are in centimeters and t is in seconds
   Find the
   (i) frequency of the wave,
   (ii) wavelength of the wave,
   (iii) speed of the wave,
   (iv) the displacement of the particle of the string at a point $x = 2$ cm and $t = 2$ s and

(v) locate first two points on the string away from the point x = 2 cm in the $+x$ direction which have the same displacement and velocity as the x = 2 cm at all the time.

(b) A single small size machine at a factory generates sound intensity level of 70 dB in the working area. If the permissible sound intensity level is 90 dB in the respective country, approximately how many more such machines can be installed in the factory in keeping with the permissible sound intensity level. Explain why the sound intensity level is defined in a log scale rather than a linear scale.

3. (a) Draw a phasor diagram for a series L-C-R circuit connected to a voltage supply in the form of $V = V_o \sin\omega t$ and show that the magnitudes of the total impedance and the phase difference are given by $[R^2 + (\omega L - 1/\omega C)^2]^{1/2}$ and $\tan^{-1}[(\omega L - 1/\omega C)/R]$, respectively. Here, all the symbols have their usual meaning. Assume that the magnitude of the inductive reactance is greater than that of the capacitive reactance.

(b) A series L-C-R circuit connected to a voltage supply in the form of $V = V_o \sin(150\pi)t$ is at resonance. Then, the rms voltages across the resistance (R) and the inductance (L) have found to be 100 V and 2000 V respectively. If R = 20 Ω,
find the
(i) value of V_o of the voltage supply
(ii) value of the inductance (L),
(iii) capacitance (C) and
(iv) Q-factor at resonance.

If the frequency of the voltage supply in the above circuit is increased to 100 Hz, would the circuit become inductive or capacitive? Give reasons to your answer.

- 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 the Sinhala and English versions of the question 4 to the supervisor or invigilator along with the answer script of questions 1,2 & 3.**

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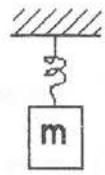
4. (i) A particle undergoing simple harmonic motion with an amplitude of A has a speed of v at a displacement of half amplitude (i.e. at $A/2$). Its maximum speed will be

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

(ii) The metal block m shown in the figure is stretched further down vertically from its equilibrium position at rest in air and then released. Then it will most probably undergo

(a) Damped vibrations.
(b) Free vibrations (undamped).
(c) Forced vibrations.
(d) Critically damped motion.
(e) Over damped motion.



(iii) $y\,(x,t) = 1.2\,\sin\,(2\pi/3)(15t - x)$ represents a

(a) Traveling wave in negative x direction.
(b) Traveling wave in positive x direction.
(c) Traveling wave in negative y direction.
(d) Traveling wave in positive y direction.
(e) Stationary wave.

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(iv) Consider the wave equation $y\ (x,t) = 40\ sin2\pi(2t - 0.05x)$ where x and y are in meters and t in seconds. The speed of this wave is

(a) 0.025 m/s (b) 0.1 m/s (c) 40 m/s (d) 60 m/s (e) 1600 m/s

(v) The intensity of sound at a point P is increased 1000 times its original value. The corresponding change in sound intensity level at P in dB is

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

(vi) Resultant displacement produced by the superposition of two oscillations given by $y_1 = A\ sin(\omega t - kx)$ and $y_2 = A\ sin(\omega t + kx)$ is

(a) $y = A\ sin2(\omega t + kx)$
(b) $y = A\ sinkx\ sin(\omega t - kx)$
(c) $y = 2A\ sin(\omega t - kx)$
(d) $y = 2A\ sin\omega t$
(e) $y = 2A\ cos\ kx\ sin\omega t$

(vii) Select the correct statement about tsunami waves

(a) Tsunami waves are very similar to normal wind-driven sea waves.
(b) Tsunami waves can not have speeds greater than 100 km/hr in the deep sea.
(c) Earthquakes are the only source which can generate Tsunami.
(d) When Tsunami waves approach sea shore, its amplitude increases but the wavelength decreases.
(e) Tsunami waves can never travel a distance more than 100 km in the deep sea.

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(viii) Fourier's theorem is applicable in

(A) periodic oscillations only.
(B) resolving a given complex periodic oscillation into its sinusoidal component oscillations.
(C) synthesizing complex oscillations.

The correct statement/s is/are

(a) only (A) (b) only (B) (c) only (A) and (C)

(d) only (B) and (C) (e) all

(ix) The time constant of a series CR circuit consisting of a resistance (R) of 50 Ω is 20 ms. The value of the capacitance (C) in the circuit is

(a) 4 μF (b) 100 μF (c) 400 μF (d) 1000 μF (e) 2500 μF

(x) Select the **false** statement

(a) A CR circuit can be used as an integrator circuit.
(b) A CR circuit can be used as a differentiator circuit.
(c) An ideal LC circuit dissipates no power.
(d) LC oscillations can occur even in a real LC circuit without dissipating any power.
(e) Voltage (emf) induced across an ideal inductor is proportional to the rate of change of current through the coil.

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(xi) In a series ac circuit consisting of an ideal inductor and a resistor, the current

(a) decreases non-linearly with the increase of the frequency of the power supply.
(b) increases non-linearly with the increase of the frequency of the power supply.
(c) increases linearly with the increase of the frequency of the power supply.
(d) decreases linearly with the increase of the frequency of the power supply.
(e) first increases and then decreases with the increase of frequency.

(xii) A charged capacitor having a capacitance (C) of 2 μF and a charge of 10 μC is connected across an ideal inductor having an inductance (L) of 0.2 H so that LC oscillations occur. The maximum current in the circuit is (approximately)

(a) 16 mA (b) 64 mA (c) 128 mA (d) 256 mA (e) 512 mA

(xiii) The rms value of the current through an ideal capacitor connected across an voltage supply given in the form of $V = 50 \sin(100t)$ is 4 A. The value of the capacitive reactance (X_C) is (approximately)

(a) 0.88 Ω (b) 8.8 Ω (c) 6.8 Ω (d) 200 Ω (e) 250 Ω

(xiv) In a series L-C-R circuit connected across a voltage supply with V_{rms} of 100 V at 50 Hz, the power factor = 1. If the quality factor (Q) of the circuit is 50, the rms value of the voltage across the inductor is

(a) 0.5 V (b) 50 V (c) 100 V (d) 2500 V (e) 5000 V

(xv) Consider the following three statements regarding ac LCR circuits

(A) For a given LCR circuit, phase difference between the voltage and the current depends on the frequency of the power supply.
(B) In parallel LCR circuits, the impedance is a minimum at resonance.
(C) In series LCR circuits, real power dissipation is a maximum at resonance.

The correct statement/s is/are

(a) only (A) (b) only (B) (c) only (A) and (C)

(d) only (A) and (B) (e) all

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