L-1/T-2/EEE  
Date: 06/02/2012  
BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA  
L-1/T-2  B. Sc. Engineering Examinations 2010-2011  
Sub: EEE 105 (Electrical Circuits II)  
Full Marks: 210  Time: 3 Hours  
The figures in the margin indicate full marks.  
USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A
There are FOUR questions in this Section. Answer any THREE.

1. (a) If a current \( I = I_m \sin \omega t \) flows through a series RC circuit, derive the expressions for applied voltage, instantaneous power, real power and reactive power. Also draw the wave shape of power.  

(b) A resistance of 10 \( \Omega \) is in series with a 303 \( \mu \)F capacitor. If the voltage drop across the capacitor is 150 \( \sin(220t - 60^\circ) \) volts, find the expression of the voltage drop across the entire series circuit. Also find the expression of the current flowing through the circuit.

2. (a) The power consumed by both branches of the circuit shown in Fig. for Q. 2(a) is 2200 W. Calculate the values of \( I_1, I_2 \) and power of each branch.  

(b) Calculate the effective value of the current waveform shown in Fig. for Q. 2(b) and the average power delivered to a 12 \( \Omega \) resistor when the current flows through the resistor.

3. (a) For a series RLC circuit, show that \( \omega_0 = \sqrt{\omega_1 \omega_2} \), where \( \omega_0 \) is the angular frequency at resonant frequency and \( \omega_1, \omega_2 \) are the angular frequency corresponding to half-power points.  

(b) How much is dissipated in \( R \) at resonance for the circuit shown in Fig. for Q. 3(b).

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4. (a) A branch containing 5 Ω resistance in series with an inductance of 7.96 mH is in parallel with another branch consisting of a resistance of 6 Ω in series with a capacitance of 176.83 μF. If a voltage, \( e = 100 \sin(\omega t + 30°) - 50 \cos(3\omega t - 30°) \) volts is applied across the parallel branch, find the current in each branch, total current, total power dissipated and the equation of resultant current.

(b) Obtain the Thevenin equivalent circuit at terminals ab for the circuit shown in Fig. for Q. 4(b).

5. (a) What is the physical significance of dot mark in magnetically coupled circuit? Describe the procedure of obtaining dot marked equivalent circuit of a physical system of windings and the procedure of using dot marked circuit for analysis by mesh current method.

(b) Determine the power absorbed by 10 Ω resistor in the circuit shown in Fig. for Q. 5(b).
6. (a) For a balanced 3-phase system, show that the phase relation between line voltage and line current is the same whether the load is Y-connected or Δ-connected and this relation can be represented by a three origin vector diagram. Draw the three origin vector diagram for abc sequence 80% lagging pf load.

(b) Determine the wattmeter readings \( W_1 \) and \( W_2 \) in Fig. for Q. 6(b). (Assume abc sequence).

7. (a) Define characteristic impedance of a two port network. Show for a symmetrical \( \pi \)-section that characteristic impedance is the geometric mean of its open circuit and short circuit impedances.

(b) Show that a low pass \((R_1C_1)\) filter and a high pass \((C_2R_2)\) filter may be cascaded in series to work as band pass filter. If \( R_2 = 2R_1 \) and \( C_2 = 2C_1 \) then determine the cutoff frequencies of the cascaded band pass filter in terms of \( R_1 \) and \( C_1 \).

8. (a) Suppose a voltage \( v = V_m \sin(\omega t + \lambda) \) is applied to a series RL circuit at \( t = 0 \). Find the current \( i \) for \( t > 0 \). Assume \( i(0-) = 0 \). Hence prove that if RL is highly inductive then transient effect would be maximum if the switch is closed at the instant \( v = 0 \).

(b) Determine the current \( i \) at \( t = 2 \times 10^{-3} \) sec for the circuit shown in Fig. for Q. 8(b). Assume that the switch was at position-1 for a long time.
SECTION – A

There are FOUR questions in this section. Answer any THREE.

1. (a) Define Coulomb's law in electrostatics. Distinguish between Coulomb's force and Gravitational force. With the help of a suitable example show that charge is conserved. (10)

(b) Fig. 1(b) shows a circular plastic disk of radius R that has a positive surface charge of uniform density $\sigma$ on its upper surface. What is the electric field at point P a distance x from the disk along its central axis? (15)

(c) A particle having a charge of $-2.0 \times 10^{-9}$ coul is acted on by a downward electric force of $3.0 \times 10^{-6}$ N in a uniform electric field. (i) What is the strength of the electric field? (ii) What is the magnitude and direction of the electric force exerted on a proton placed in this field? (iii) What is the gravitational force on the proton? (iv) What is the ratio of the electric to gravitational forces? (10)

2. (a) Define electric flux $\phi_E$. Compare electric flux with magnetic flux $\phi_B$ and gravitational flux $\phi_G$. Write down Gauss's law for incompressible fluids. (10)

(b) Define line, surface and volume charge density. Apply Gauss's law to calculate electric field at a distance r from a (i) line of charge (ii) A sheet of charge (iii) A charged conductor. (15)

(c) A 100-eV electron is fired directly toward a large metal plate that has a surface charge density of $-2.0 \times 10^{-6}$ coul/m$^2$. From what distance must the electron be fired if it is to just fail to strike the plate? (10)

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3. (a) Discuss electrical resistivity from the atomic point of view. Write down Ohm's law in terms of the equivalent microscope parameters. Draw i-v curves for a conductor, semiconductor and a thermistor. Also show R-T curve of mercury at very low temperature (0 – 6 K). Why resistivity of mercury disappears at 4 K? (10)

(b) Show that the (electrical) resistivity of a conductor is

\[ \rho = \frac{mv}{ne^2} \]

where the symbols have their usual meaning. What are the mean time \( \tau \) between collisions and the mean free path for free electrons in copper? (15)

(c) A copper wire and a iron wire of equal length \( l \) and diameter \( d \) are joined and a potential difference \( V \) is applied between the ends of the composite wire. Calculate (i) the electric field strength in each wire, (ii) the current density in each wire, and (iii) the potential difference across each wire. Assume that \( l = 10 \) meters, \( d = 2.0 \) mm, and \( V = 100 \) volts. (10)

4. (a) What do you mean by a closed-isolated system. Why the sum of the internal forces for a system of particles is zero? (4+6)

(b) Derive the equation of torque for a system of particles. (15)

(c) A firecracker placed inside a coconut of mass \( M \) initially at rest on a frictionless floor blows the coconut into three pieces that slide across the floor. The angle between piece 1 and 3 is 100°, whereas the angle between piece 2 and 3 is 130°. Piece 3 with mass 0.35 \( M \) has the final speed 5.5 m/s. (i) What is the speed of piece 2 with mass 0.25 \( M \)? (ii) What is the speed of piece 1? (10)

SECTION – B

There are FOUR questions in this section. Answer any THREE.

5. (a) State the Kepler's laws of planetary motion. Show that the rate \( \frac{dA}{dt} \) at which an object sweeps out an area \( A \) is constant in planetary motion. (3+7)

(b) Derive the equation of the total mechanical energy for a satellite motion. How this energy depends on semimajor axis for different eccentricity? Why the total mechanical energy for a satellite motion is negative? If we supply a proper amount of kinetic energy of the satellite, what would be the type of satellite's orbit? (6+9)

(c) An object orbits about the sun with a period of 75 years and, in 1985, had its perihelion distance of \( 8.7 \times 10^{10} \) m. What is the object's aphelion distance? Determine the ratio of the object's speed at perihelion to that at aphelion. (10)

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6. (a) What is a wave function? Derive the one dimensional time dependent Schrödinger equation.
(b) State and prove uncertainty principle.
(c) A hydrogen atom is \(5.3 \times 10^{-11}\) m in radius. Use uncertainty principle to estimate the minimum energy an electron can have in this region.

7. (a) Define relativistic momentum and prove that the relativistic form of Newton’s second law is:

\[ F = m_0 \frac{dv}{dt} \left(1 - \frac{v^2}{c^2}\right)^{-\frac{3}{2}} \]

where the symbols have their usual meaning.
(b) Derive kinetic energy expression in relativistic mechanics and show that this takes the form of well known kinetic energy expression of classical mechanics.
(c) Show that, in two inertial frames, the conservation of total energy is equivalent to the conservation of relativistic mass.

8. (a) What is Compton effect?
(b) (i) Show that the change in wavelength of an x-ray photon after scattering from a free electron is independent of the wavelength of the incident ray. (ii) From Compton effect, show that the maximum wavelength change is twice the Compton wavelength.
(c) If x-rays of wavelength 10 pm are scattered from a target through 45°, find the maximum kinetic energy of the recoil electrons in kilo-electron volt.
SECTION – A

There are FOUR questions in this Section. Answer any THREE.

1. (a) Form the differential equation of least order by eliminating arbitrary constants \(a, b, c\) from \(y = ae^{2x} + be^{-3x} + ce^x\).

(b) Solve:
\[
\frac{x dy + y dx}{y dx - y dx} = \left(\frac{a^2 - x^2 - y^2}{x^2 + y^2}\right).
\]

(c) Solve:
\[y + px = x^4 p^2.\]

2. (a) Solve:
\[
\frac{dy}{dx} + \frac{x - y - 2}{x - 2y - 3} = 0.
\]

(b) A series circuit consists of a constant inductance of 1 henry, a variable resistance \(R\), and a constant electromotive force \(E\). If \(R = \frac{1}{5 + t}\) at any time \(t > 0\) and \(i(0)=0\), then find \(E\) when \(i(5)=30\).

(c) Solve:
\[
(2xy^4 + 2x^4 + y)dx + (x^2 y^4 - x^2 y^2 - 3x)dy = 0.
\]

3. (a) Solve the differential equation \(\frac{d^2 y}{dx^2} + 2\frac{dy}{dx} + y = \frac{e^{-x}}{x}\) by the method of variation of parameters.

(b) A weight attached to a spring moves up and down so that the equation of motion is \(\frac{d^2 s}{dt^2} + 16s = 0\), where \(s\) is the stretch of the spring at time \(t\). If \(s = 2\) and \(\frac{ds}{dt} = 1\) when \(t = 0\), find \(s\) in terms of \(t\).

(c) A circuit has in series an electromotive force given by \(E = 100\sin 60t\) volts, a resistor of 2 ohms, an inductor of 0.1 henry and a capacitor of \(\frac{1}{260}\) farads. If the initial current and the initial charge on the capacitor are both zero, find the charge on the capacitor at any time \(t > 0\).

4. (a) Find the general solution of \(\frac{d^2 y}{dx^2} - 6\frac{dy}{dx} + 13y = x^2 \sin x\).

(b) Solve:
\[x^2 \frac{d^2 y}{dx^2} - 3x \frac{dy}{dx} + 5y = x^2 \cos (\ln x).\]

(c) Solve the differential equation \(\left[(x + 2)D^2 - (2x + 5)D + 2\right]y = (x + 1)e^x\) by the method based on factorization of the operators.

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There are FOUR questions in this Section. Answer any THREE.

5. (a) Use Frobenius method to obtain a series solution of the differential equation

\[ 2x^2 \frac{d^2 y}{dx^2} - x \frac{dy}{dx} + \left(1 - x^2\right)y = 0 \]

(b) Solve the following partial differential equation:

\[ x^2 p - y^2 q = (x - y)z \]

Also find the particular surface which satisfies the above equation and passes through the curve \( x^2 + y^2 = 1, \ z = k \).

6. (a) Find the complete solution of the following partial differential equations:

(i) \( (1-x^2)y'' + x^2 q = 0 \)

(ii) \( 2x^4 p^2 - yz q - 3z^2 = 0 \)

(b) Use Charpit's method to find the complete integral and the singular integral (if exists) of the PDE.

\[ pq + x(2y + 1)p + (y^2 + y)q - (2y + 1)z = 0 \]

7. Solve the following higher order PDEs:

(i) \( (D_x - D_y - D_x + D_y)z = x^2 \sin(x - y) \)

(ii) \( (3D_t^2 - 2D_x^2 + D_x - 1)z = e^{2xy} \sin(x + y) \)

(iii) \( (D_x^2 + D_x D_y - 2D_y)z = 8 \sec^2(2x + y) \tan(2x + y) \)

8. (a) Solve the following PDE:

\( (6x^3 D_t^2 - xy D_x D_y - y^2 D_y^2 + 6x D_x - y D_y)z = xy \cos(\log x) \)

(b) Solve the wave equation \( \frac{\partial^2 y}{\partial t^2} = \frac{\partial^2 y}{\partial x^2} \) for the displacement function \( y(x, t) \) which satisfies the following boundary and initial conditions:

\[ y(0, t) = y(L, t) = 0; \quad t > 0 \]

\[ y(x, 0) = Lx - x^2; \quad 0 < x < L \text{ and} \]

\[ \left( \frac{\partial y}{\partial t} \right)_{t=0} = 0; \quad 0 < x < L. \]
SECTION – A

There are FOUR questions in this Section. Answer any THREE.

1. (a) What is social stratification? Explain the nature of caste system as an important system of social stratification. (10)
   (b) Briefly discuss Karl Marx’s theory of social stratification. (15)
   (c) What do you understand by social mobility? Describe different types of social mobility. (10)

2. (a) What are the sociological viewpoints for explaining poverty of a society? (15)
   (b) Use the functionalist and conflict perspectives to assess the effects of mass media on developing countries. (20)

3. (a) How does conflict theory explain the roles of culture in a society? (17)
   (b) What do you understand by social values? Justify why culture is considered as a normative system of a society. (18)

4. Write short notes on any three of the following: (35)
   (a) Cooley’s looking glass self theory
   (b) Types of socialization
   (c) White color crime
   (d) Globalization.

SECTION – B

There are FOUR questions in this Section. Answer any THREE.

5. (a) How do you define environment and pollution? What are the main sources of global warming? (10)
   (b) How can environmental destruction be brought under control? (15)
   (c) Explain the various stages of demographic transition theory. (10)
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6. (a) What are the impacts of capitalism on society? (10)
   (b) What is meant by patriarchal family? What functions does the family perform for society? (15)
   (c) Briefly discuss the various types of industries in Bangladesh. (10)

7. (a) Discuss the Durkheim’s explanation of anomie of a society. (10)
   (b) What are the hypothesis given by demographer Lee for explaining migration behaviour. (15)
   (c) Explain Peterson migration typology. (10)

8. Write short notes on any three of the following: (35)
   (a) The factors responsible for cities growth
   (b) The sources of social change
   (c) Features of capitalism
   (d) The significance and role of physical environment in social development.
SECTION – A

There are FOUR questions in this section. Answer any THREE.

1. (a) Define solution. Classify solution into different classes based on physical state of substances. Give at least one example of each class. (2+4+4=10)
(b) State and explain the effects of temperature and presence of salt on the solubility of a solid in water. (6+4=10)
(c) Classify liquid-liquid solution. With the help of a diagram describe the effect of temperature on mutual miscibility of two partially miscible liquids which have upper CST. (10)
(d) State and explain distribution low in brief. (5)

2. (a) What do you understand by osmotic pressure? State laws of osmotic pressure. Show that these are similar to those of gas laws. (3+3+4=10)
(b) Derive a mathematical relation between depression of freezing point and molecular weight of an unknown solute. (10)
(c) The melting point of phenol is 40°C. A solution containing 0.172 g acetanilide (Mol.wt = 135) in 12.54 g phenol freezes at 39.25°C. Calculate the cryoscopic constant of phenol. (10)
(d) The vapour pressure of a solution of non-volatile solutes is always less than that of its solvent. How it happens? Describe. (5)

3. (a) What is photo electric effect? Describe the Einstein's explanation of photo electric effect. (4+8=12)
(b) Why did Bohr assume that angular momentum of an electron in an orbit is quantized? (8)
(c) What are the limitations of Bohr's theory? How can Sommerfeld modification overcome these limitations? (5+10=15)

4. (a) Define (i) phase, (ii) component and (iii) degrees of freedom related phase rule giving suitable examples. Derive a mathematical relation between these for a heterogeneous system. (3x3+9=18)
(b) Derive Schrödinger wave equation and explain its importance in chemistry. (8+2=10)
(c) What do you understand by dual nature of an electron? Derive the equation which describes the dual nature of electron. (7)
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SECTION – B
There are FOUR questions in this section. Answer any THREE.

5. (a) Compare the Valence Bond and Molecular Orbital theories of the chemical bond. (5)

(b) Describe the shapes of the given molecules. (5x3=15)
   (i) PCl₅ (ii) NH₃ and (iii) XeF₄

(c) Draw the Molecular Orbital diagram of the following molecules and calculate their bond orders. (5x3=15)
   (i) O₂ (ii) CO and (iii) F₂

6. (a) Classify Lewis acid and base and explain each type with example. (8)

(b) Define the following terms:
   (i) Ionization potential (ii) Electron affinity and (iii) Electronegativity (9)

(c) Derive the thermodynamic relationship between Gibb's Free Energy (G) and equilibrium constant (K). (8)

(d) Define Heat of solution and Heat of combustion. Describe briefly how Heat of combustion measurement is carried out in the laboratory. (4+6=10)

7. (a) Why is it important to know the activation energy (Ea) of reactions? Derive a mathematical model showing the effect of temperature on the rate of reaction. Mention the different applications of this model. (3+7+4=14)

(b) The rate constants for the decomposition of a compound at 470°C and 510°C are 1.10 x 10⁻⁴ sec⁻¹ and 1.63 x 10⁻⁵ sec⁻¹, respectively. Determine the energy of activation of the system. What are half-lives of the compound at the above two temperatures? (6+4=10)

(c) The values of “Kp” and “Kc” for a gaseous homogeneous reaction may or may not be equal – Justify this statement. (7)

(d) How does pressure affect the equilibrium constant of a homogeneous gaseous reaction? (4)

8. (a) Define and explain the term "Heat of reaction" with suitable example. (5)

(b) Derive a relationship between heat of reaction at constant volume and that at constant pressure. What is the name of this relationship? (12)

(c) The heat of reaction of N₂ + 3H₂ → 2NH₃ at 27°C was found to be -21.976 kcal. What will be the heat of reaction at 50°C? The molar heat capacities at constant pressure and at 27°C for N₂, H₂ and NH₃ are 6.8, 6.77 and 8.86 cal.mol⁻¹.deg⁻¹. (10)

(d) Describe the half-life and isolation method for the determination of order of reactions. (8)

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