BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-I/T-I B. Sc. Engineering Examinations 2020-2021

Sub : **ME 101** (Introduction to Mechanical Engineering)

Full Marks : 210   Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

Assume reasonable values for missing data, if any. Symbols carry their usual meanings.

SECTION – A

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

1. (a) Make a brief comparison between vapour compression and vapour absorption refrigeration

    systems.   **(15)**

    (b) Make an energy balance of an air-conditioner of 2TR capacity having a COP of 5.   **(10)**

    (c) Write short notes on the followings: **(10)**

        (i) AHU, (ii) FCU

2. (a) Make a brief comparison between fire-tube and water-tube boilers.   **(5)**

    (b) Draw the schematic diagram of a water tube boiler and label the key components.   **(10)**

    (c) Define boiler mountings and accessories. Give two examples from each type.   **(8)**

    (d) Draw a schematic diagram of a combined-cycle power plant and show typical energy

    balance for a 100 MW CC power plant.   **(12)**

3. (a) Define 'mechatronics'. What are the key components of mechatronics?   **(5)**

    (b) Define 'robot'. Write a short note on robot drive systems.   **(10)**

    (c) Write a short note on 'machine vision system'.   **(12)**

    (d) Write short notes on the followings: **(8)**

        (i) MEMS, (ii) Robot programming modes.

4. (a) Make of a brief comparison between ductile and brittle materials.   **(5)**

    (b) Classify 'beams' and 'springs'.   **(10)**

    (c) Write short notes on the followings: **(20)**

        (i) Column end conditions.

        (ii) Journal bearing.

        (iii) Fusible plug used in boilers.

        (iv) Chiller used in central air-conditioning system.

ME 101

SECTION – B

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

5. (a) "There is a great scope of job opportunities for Mechanical Engineers all over the world" - explain the statement and mention some related industries in which Mechanical Engineers play a centre role. What are the essential duties and responsibilities of Mechanical Engineers in renewable energy sector? **(15)**

(b) What are the 5 basic types of environmental pollution and among them which one is the most harmful? What are its main compositions? Mention the health problems associated with this type of pollution. **(10)**

(c) Define a "Standard" and a "Code". What is meant by ASME, ASTM, NSPE? What are the fundamental canons regarding the "Code of Ethics for Engineers"? **(10)**

6. (a) What is wind energy? Write down the expression for power extracted by a wind turbine. Define, "power coefficient", "solidity", and "tip speed ratio" related to wind turbine. Wind speed at 10 meter and at 50 meter heights from ground level are found in a locality as 5 m/s and 7 m/s respectively. Calculate the "power law index" for that locality. **(15)**

(b) What is solar energy? How a P-N junction is made? Describe with a neat sketch how solar cell converts sunlight into useful electrical power. Draw a typical I-V characteristic curve for a solar cell connected to a variable load. **(10)**

(c) What is nuclear energy? How nuclear energy is available from U^{235}? Define "chain reaction" with an example. With a schematic diagram, show the basic components of a nuclear power plant. **(10)**

7. (a) With a neat free hand sketch for a 4-stroke cycle ideal CI engine, show the approximate position of piston, cylinder, connecting rod and crank assembly 90° after the beginning of exhaust stroke. Also show the status of intake and exhaust valves at this position. Draw the corresponding PV diagram for this engine and put an asterisk(*) on this PV diagram to mark its location. **(15)**

(b) What are the 4 reasons due to which high temperature of IC engines are objectionable? Classify IC engine cooling systems. Draw and label a cooling system used in an IC engine motor bike. **(10)**

(c) A motor bike has its piston stroke length equal to its bore. Its compression ratio is 9 with a clearance volume of 12.5 cc. Calculate its engine capacity, bore and crank radius. **(10)**

ME 101

8. (a) Draw the block diagram of a closed cycle gas turbine plant employing intercooling, reheating and regeneration. Draw the corresponding T-S diagram. **(15)**

(b) Identify the component of the in Jet engine as shown in the figure for # 8(b) as labelled "1" through "8" (for example, 9 = nozzle; please do not draw the figure). How many stages are there respectively in LP compressor and in HP compressor in this figure? **(10)**

(c) Distinguish between a Fan, a Blower and a Compressor. A pump lifts water from underground water tank of a building to its root-top water tank. For this pump, total static head is 20 meter and static discharge head is 13 meter. Determine the pumps state suction lift. **(10)**
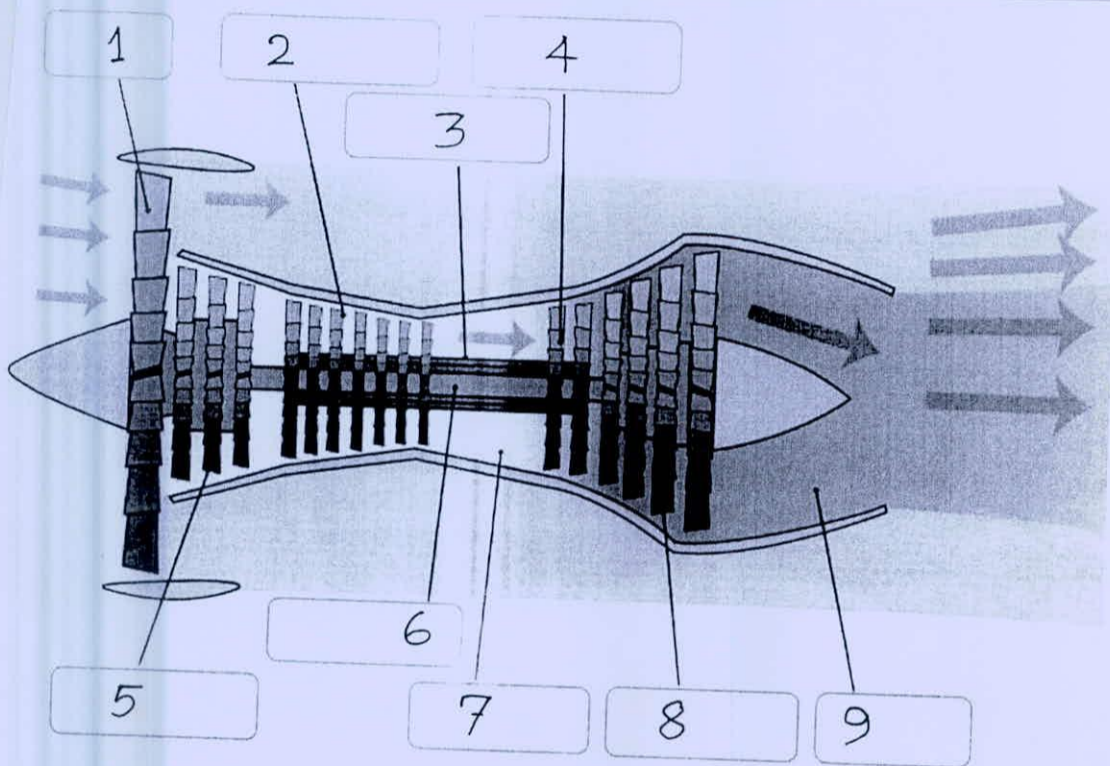
Figure for # 8 (b)

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1   B. Sc. Engineering Examinations 2020-2021

Sub: **PHY 105** (Structure of Matter, Electricity, Magnetism and Modern Physics)

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** questions.

1. (a) Distinguish between crystalline and amorphous solids. Discuss all possible difference between lithium (Li) and copper (Cu) crystals from the crystallographic point of view. **(12)**

    (b) What are the differences between orthorhombic and tetragonal crystal systems? Draw the unit cells of their various space lattices and find out the number of atoms per unit cell in each space lattice of these crystal systems. **(16)**

    (c) Suppose you are given a crystalline material whose atomic weight is M_x and atomic radius is R. Its crystalline nature is face centered cubic. Derive an expression for density of this crystal using above information. **(7)**

2. (a) Describe the term X-ray diffraction related to Crystallography. What information do you get from X-ray diffraction of a crystal? **(10)**

    (b) What are the Miller indices? Briefly discuss the procedures of obtaining Miller indices for a crystal plane. **(10)**

    (c) What is crystalline nature of platinum metal? Sketch (100) plane of platinum crystal in a typical unit cell. Atomic radius of platinum is 0.130 *nm*. (i) What is the area of this plane? (ii) Calculate number of *atoms/m²* of (100) plane of platinum crystal. (iii) Calculate density and packing factor for platinum crystal. Platinum has a molar mass of 195 *g/mol*. **(15)**

3. (a) Why the interatomic bond exists in solids? Explain why diamond has higher melting temperature (~ 4000 °C) than that of iron (~ 1500 °C)? Briefly discuss the existing bonds in these materials. **(12)**

    (b) Distinguish between cohesive energy and lattice energy of *NaCl* crystal. Derive an expression for the cohesive energy of *NaCl* crystal. **(18)**

    (c) Draw the band diagrams for typical metal, insulator and semiconductor. **(5)**

4. (a) What do you mean by Hall-effect? Explain how the electric field is set up during Hall-effect. For a conducting strip in a Hall-effect situation, draw the vectors for the velocity, magnetic force, and electric force of the conduction electron. **(15)**

PHY 105/ME
Contd... Q. No. 4

(b) Describe how the density of the charge carrier can be determined by Hall-effect. **(10)**

(c) The current density $\vec{J}$ inside a long, solid, cylindrical wire of radius $a = 3.1$ mm is in the direction of the central axis, and its magnitude varies linearly with radial distance r from the axis according to $J = J_0\left(\frac{r}{a}\right)$ where $J_0 = 310$ A/m^2. Find the magnitude of the magnetic field at (i) $r = 0$, (ii) $r = a/2$, and (iii) $r = a$. **(10)**

SECTION – B

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

5. (a) What do you mean by electric dipole? The potential energies associated with four orientations of an electric dipole in an electric field are (A) $-5U_0$, (B) $-7U_0$, (C) $3U_0$, and (D) $5U_0$, where U_0 is positive. Rank (by explaining the reason explicitly) the orientations according to (i) the angle between the electric dipole moment and the electric field and (ii) the magnitude of the torque on the electric dipole, greatest first. **(10)**

(b) Fig. for Q. No. (5b) shows a plastic rod with a uniform charge $-Q$. It is bent in a 120° circular arc of radius r and symmetrically placed across an x axis with the origin at the center of curvature P of the rod. In terms of Q and r, what is the electric field due to the rod at point P? **(10)**

(c) Fig. for Q. No. (5c) shows a closed Gaussian surface in the shape of a cube of edge length 2.0 m, with one corner at $x_1 = 5.0$ m, $y_1 = 4.0$ m. The cube lies in a region where the electric field vector is given by $\vec{E} = 3x\hat{i} - 4y^2\hat{J} + 3\hat{k}$ N/C, with x, y in meters. What is the net charge contained by the cube? **(15)**
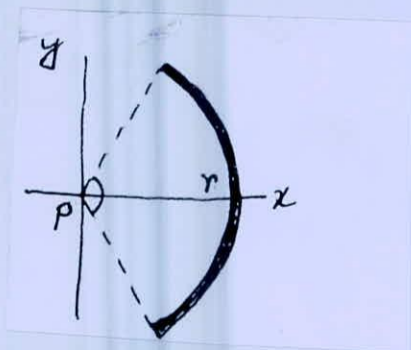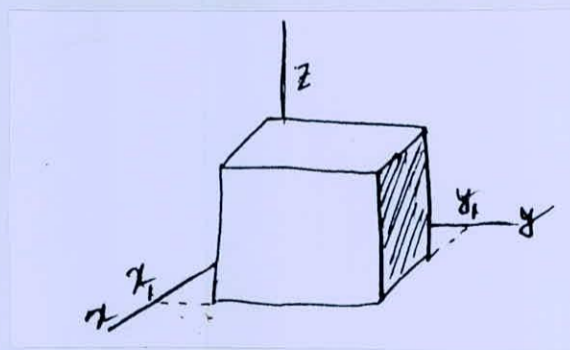

Fig. for Q. No. (5b)

Fig. for Q. No. (5b)

6. (a) What do you mean by electrical potential? For a non-uniform electric field establish a relation between the electric potential and the electric filed. Fig. for Q. No. (6a) gives the electric potential V as a function of x. After explaining the reason rank the five regions according to the magnitude of the x component of the electric field within them, greatest first.
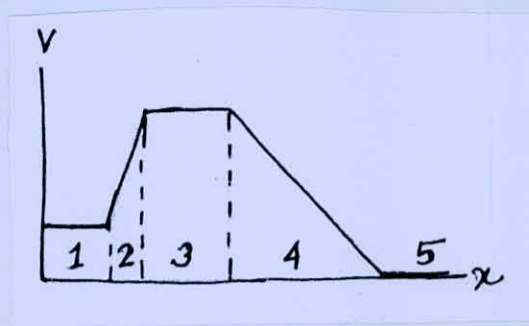
PHY 105/ME
Contd... Q. No. 6(a)

Fig. for Q. No. (6a)

(b) Derive the Gauss's law in the presence of a dielectric materials. **(10)**

(c) What is the current in a wire of radius $R = 3.40$ mm if the magnitude of the current density is given by (i) $J_a = J_0\left(\frac{r}{R}\right)$ and (ii) $J_b = J_0\left(1 - \frac{r}{R}\right)$, in which r is the radial distance and $J_0 = 5.50 \times 10^4$ A/m^2 ? **(10)**

7. (a) Explain the failure of Galilean transformation in special theory of relativity. **(5)**

(b) Derive the transformation equations which can address the limitations of Galilean transformation. **(20)**

(c) Explain relativity of simultaneity. An observer detects two explosions, one that occurs near her at a certain time and another that occurs 2 ms later 100 km away. Another observer finds that the two explosions occur at the same place. What time interval separates the explosions to the second observer? **(10)**

8. (a) Why do classical wave theories cannot explain the energy distribution of the black body radiation spectrum? **(5)**

(b) What do you understand by photo-electric effect and explain if using Einstein's equation. **(20)**

(c) What are nuclear fission and chain reaction? Describe the three situations of the chain reaction. A city requires on an average 1000 megawatts of electric power per day, and this is to be supplied by a nuclear fission reactor of efficiency 30%. Using U-235 as a nuclear fuel, calculate the amount of fuel required for one day's operation. Energy released per fission of U-235 nuclide is 200 MeV. **(10)**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1   B. Sc. Engineering Examinations 2020-2021

Sub: **CHEM 109** (Chemistry – I)

Full Marks: 210   Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

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

1.   (a) Give a molecular interpretation of the solution process, when an ionic solid is mixed with a polar solvent like water. **(15)**

(b) Use the concept of solubility of the gas in liquid and explain the term 'thermal pollution. Relate it with the ecological imbalance? **(12)**

(c) Alloys are solid solution-justify the statement **(8)**

2.   (a) An aqueous solution of sugar or glucose boils at a temperature higher than that of pure water. Explain the fact with your knowledge of vapor pressure lowering due to the addition of non-volatile and non-electrolyte solute in the solvent. **(15)**

(b) Compare 'membrane solution theory' and 'vapor pressure theory' to explain osmosis. **(12)**

(c) Automotive antifreeze consists of ethylene glycol, $CH_2(OH)CH_2(OH)$, is a nonvolatile and nonelectrolyte. Calculate the boiling point and freezing point of a 25.0 mass % solution of ethylene glycol in water. Use the normal boiling point and freezing point of water at 1 atmosphere pressure. [K_b = (0.51 °C/m, K_f = 1.86 °C/m] **(8)**

3.   (a) Identify the main difference between the differential rate and integral rate in chemical kinetics. Interpret the nature of concentration vs time plot derived from the integrated rate expression of first order and zero order reaction. **(15)**

(b) $A \xrightarrow{\ k_1\ } B \xrightarrow{\ k_2\ } C$ **(12)**

For the above consecutive reaction, where [A], [B] and [C] are the concentrations of the A, B and C, respectively. k_1 and k_2 are the rate constants. Draw the reaction profile (Concentration vs. Time) for the two extreme cases and explain the nature of the curves. Case-i; $k_1 \gg k_2$, and Case-ii, $k_2 \gg k_1$.

(c) Define the energy of activation for a reaction. Suppose, the energy of activation is zero. Calculate the rate constant at 300 K if rate constant. $k = 1.6 \times 10^6 s^{-1}$ at 280 K. **(8)**

CHEM 109

4. (a) Draw the phase diagram of sulfur.   **(15)**

    i) Identify two-phase and three-phase equilibriums exist in the diagram.

    ii) Show that the existence of monoclinic sulfur is not possible if a metastable equilibrium is formed.

    iii) A four-phase equilibrium is not possible in the sulfur system-Justify.

    (b) Carbon dioxide is gas and water is liquid under normal atmospheric conditions. Explain the fact in terms of the phase diagram.   **(10)**

    (c)A calorimeter is to be used to compare the energy content of some fuels. In the calibration of the calorimeter, an electrical resistance heater supplies 100.0 J of heat and a temperature increase of 0.8508°C is observed. Then 0.245 g of a particular fuel is burned in this same calorimeter and the temperature increases by 5.238C. Calculate the energy density of this fuel, which is the amount of energy liberated per gram of fuel burned.   **(10)**

SECTION – B

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

5. (a) Show how the shape of the periodic table is related to quantum numbers. **(10)**

    (b) Examine the result when describe Broglie's equation applies to Bohr's theory. **(10)**

    (c) Is it possible to depict the three-dimensional shapes of molecules by Lewis structures? Explain-Why?   **(10)**

    (d) Investigate the effect of magnetic field on the spectra of atoms.   **(5)**

6. (a) Draw the molecular orbital for s-p overlap and lateral overlap.   **(10)**

    (b) Show how the LCAO approximation gives rise to bonding and antibonding orbitals. **(10)**

    (c) Bond order provide information about the existence of a molecule- explain with example.   **(10)**

    (d) Discuss the three-dimension shape of PF_5 molecule.   **(5)**

7. (a) List the types of electromagnetic radiation, starting with the radiation having the longest wavelength and ending with radiation having the shortest wavelength. The first line of the Balmer series occurs at a wavelength of 656.3 nm. What is the energy difference between the two energy levels involved in the emission that results in this spectral line?   **(10)**

CHEM 109

Contd... Q. No. 7

(b) Illustrate the physical concept of uncertainty principle. Explain the significance of the wave function. **(10)**

(c) From the relationship $K_aK_b = K_w$, what can you deduce about the relative strengths of a weak acid and its conjugate base? Categorize salts according to how they affect the p^H of a solution. **(10)**

(d) Show an example of combination of orbitals where their symmetry do not match. **(5)**

8.   (a) Describe the geometries of the following cubic cells: **(10)**

Simple cubic, body-centered cubic, face-centered cubic.

(b) Europium crystallizes in a body-centered cubic lattice (the Eu atoms occupy only the lattice points). The density of E is 5.26 g/cm^3. Calculate the unit cell edge length in pm. **(10)**

(c) Explain Lanthanoid contraction. Calculate magnetic moment (μ_s) and number of unpaired electron of Cr^{2+}, Co^{2+} and Mn^{2+} ions. **(10)**

(d) Classify polymers with examples. **(5)**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1   B. Sc. Engineering Examinations 2020-2021

Sub : **EEE 159** (Fundamentals of Electrical Engineering)

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) Find the value of the resistor R (in ohms) which will result in $i_0 = 2.206$ A in the circuit of Fig. for Q. 1(a).   (18)
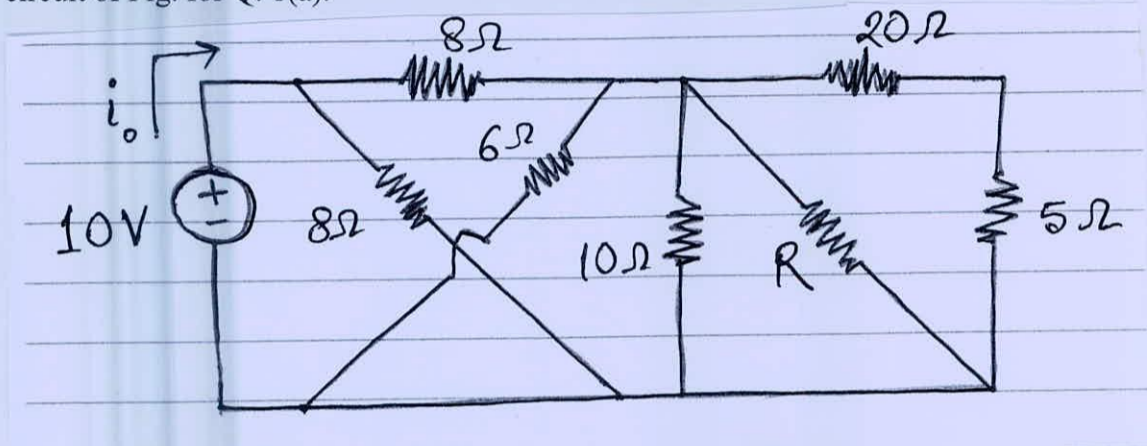
Fig. for Q. 1 (a)

(b) Find the power dissipated across all resistors and show that the principle of conservation of power holds true for the circuit in Fig. for Q. 1(b).   (17)
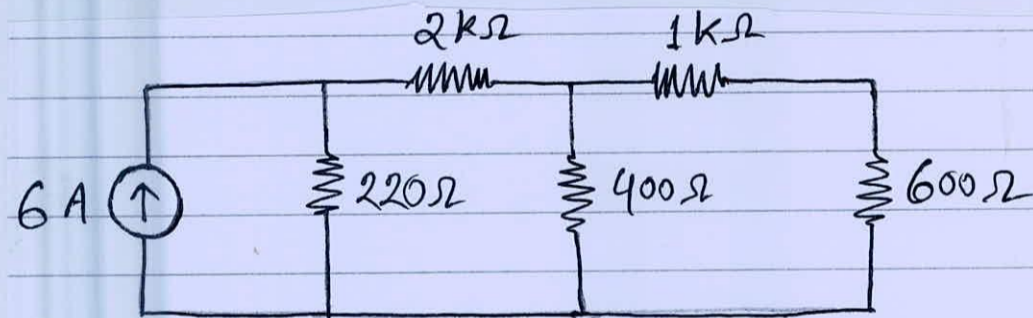
Fig. for Q. 1 (b)

2. (a) From the circuit given in Fig. for Q. 2(a), draw a rough sketch of i_0 versus i_s.   (20)
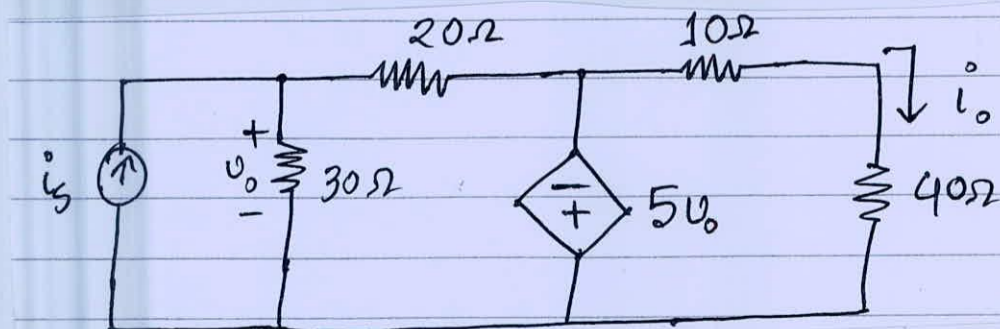
Fig. for Q. 2 (a)

EEE 159/ME

Contd ... Q. No. 2

(b) Find the node voltages V_1 and V_2 using an appropriate method from the given circuit in Fig. for Q. 2(b). (15)
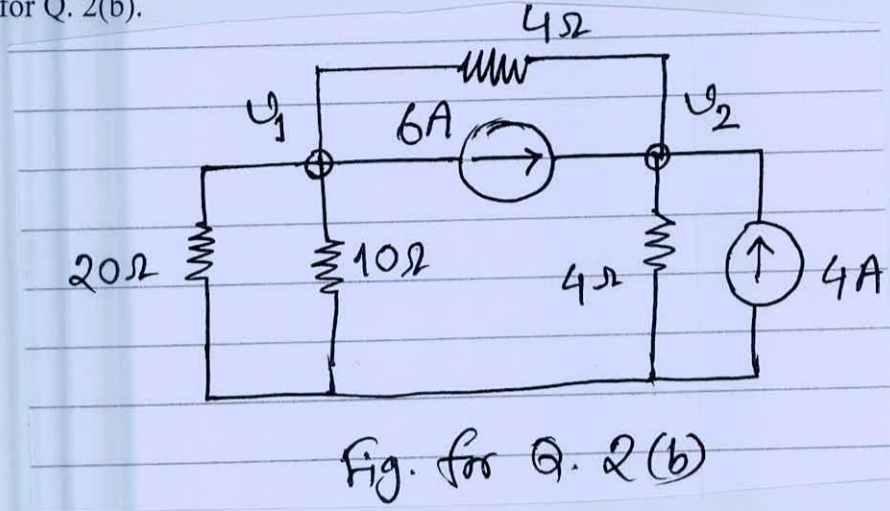
Fig. for Q. 2(b)

3. (a) Determine i_0 and v_0 in the circuit of Fig. for Q. 3(a) using the principle of superposition. (20)
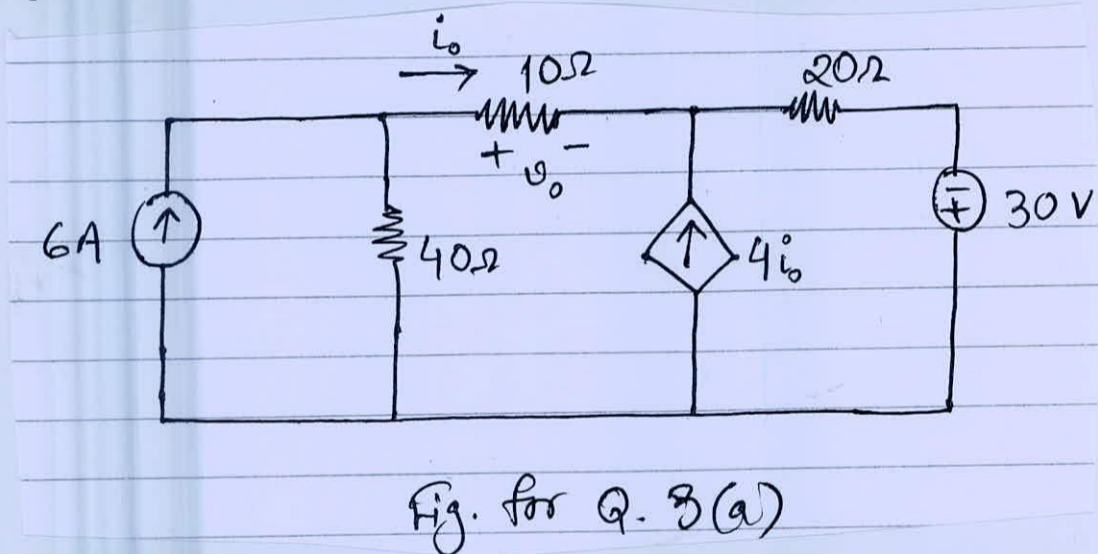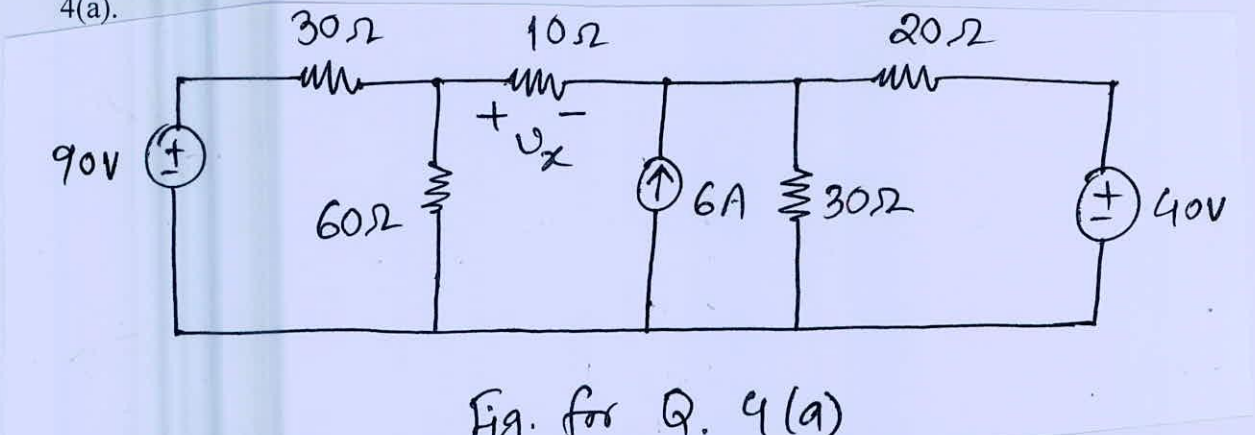
Fig. for Q. 3(a)

(b) Determine the load resistance R_L which will maximize the average power drawn from the circuit as shown in Fig. for Q. 3(b). Also find the maximum average power. (15)
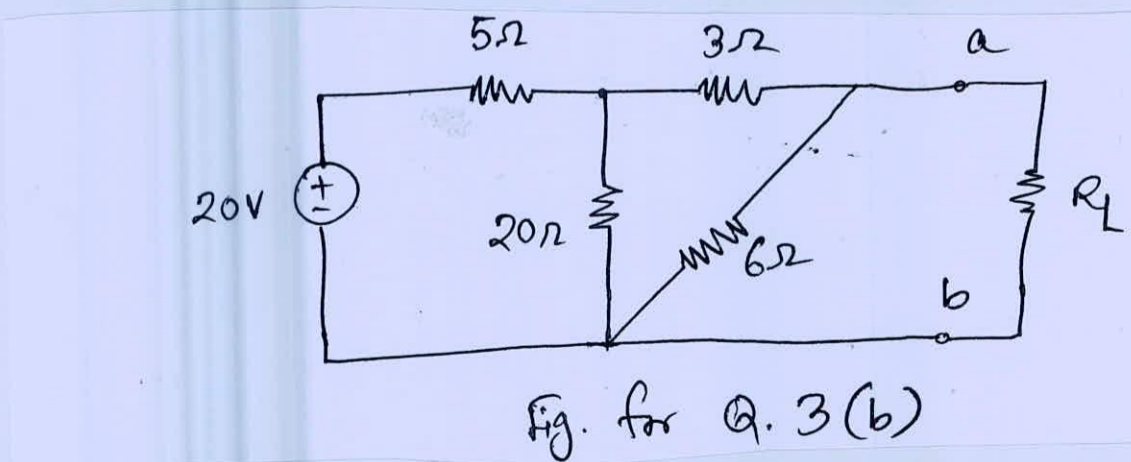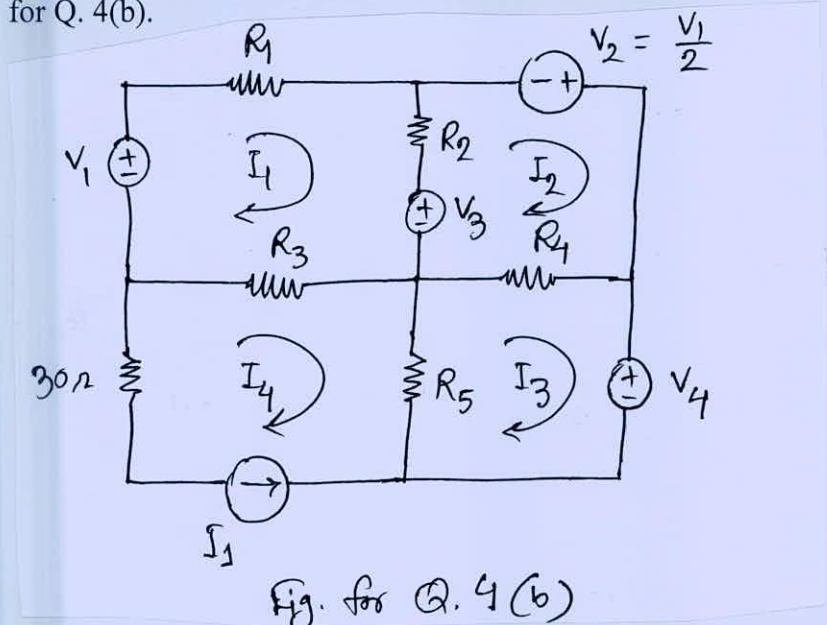
Fig. for Q. 3(b)

EEE 159/ME

4. (a) Use source transformation to find the labeled voltage V_x from the circuit in Fig. for Q. 4(a). (17)

Fig. for Q. 4(a)

(b) Find the values of the unspecified resistances, voltage and current sources for the circuit in Fig. for Q. 4(b). (18)
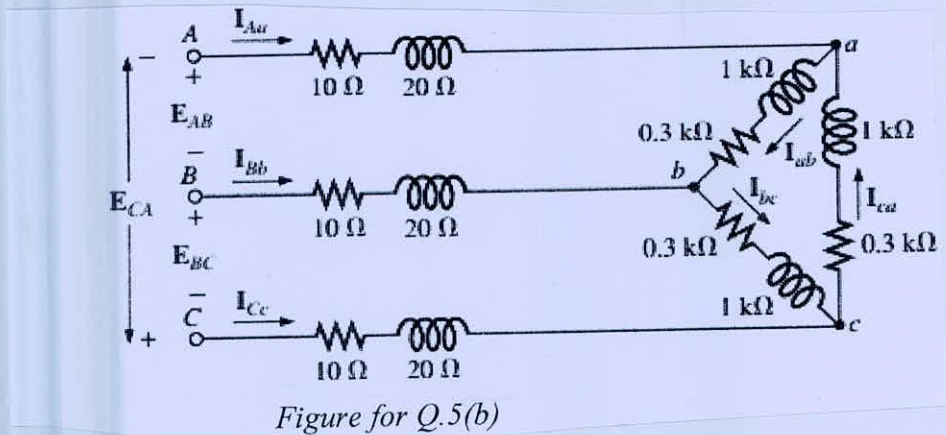

Fig. for Q. 4(b)

SECTION – B

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

All the symbols have their usual meanings. Assume reasonable values for missing data.

5. (a) Why three phase system is the most common amongst all poly phase systems? (10)

(b) For the circuit of Fig. for Q. 5(b), (15)

$$V_{ab} = 15kV \angle 0, \quad V_{bc} = 15kV \angle -240, \quad V_{ca} = 15kV \angle -120$$

Find the current I_{Aa} and voltage E_{BC}, E_{CA}.

Figure for Q.5(b)

EEE 159/ME

Contd … Q. No. 5

(c) Find out the current in the resistor R_L in the circuit of Fig. for Q. 5(c). (10)
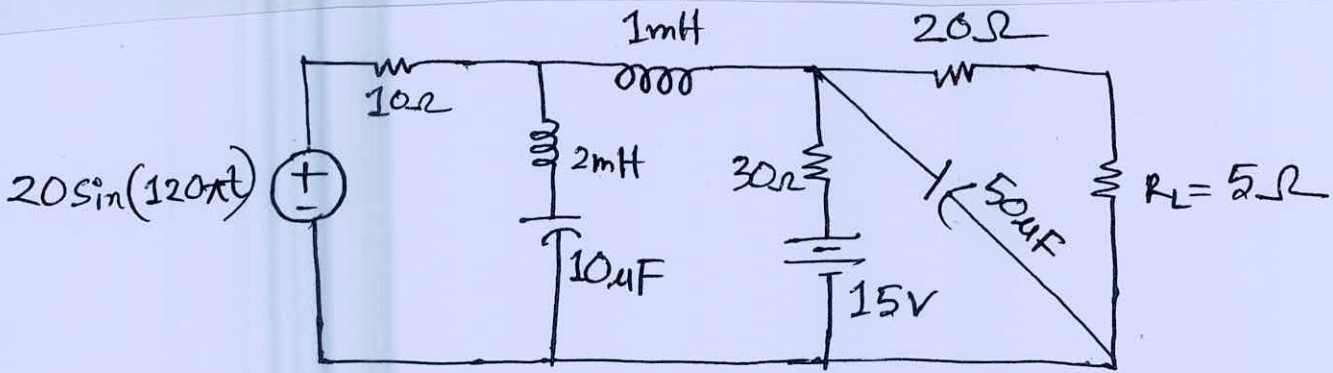

Figure for Q. 5(c)

6. (a) The following AC waveform shown in the figure Q. 6(a) is current passing through a 120-ohm resistor. Find average current (Iavg), RMS voltage (Vrms) and average power (Pavg) of the resistor. (20)

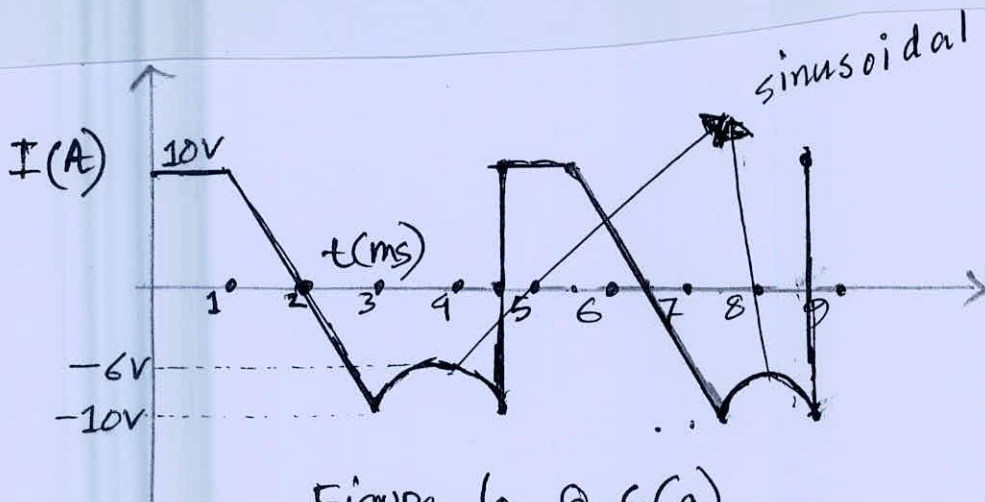Figure to Q. 6(a)

(b) For the circuit in Fig. for Q. 6(b), prove the conservation of AC power theory. (15)

Figure for Q. 6(b)

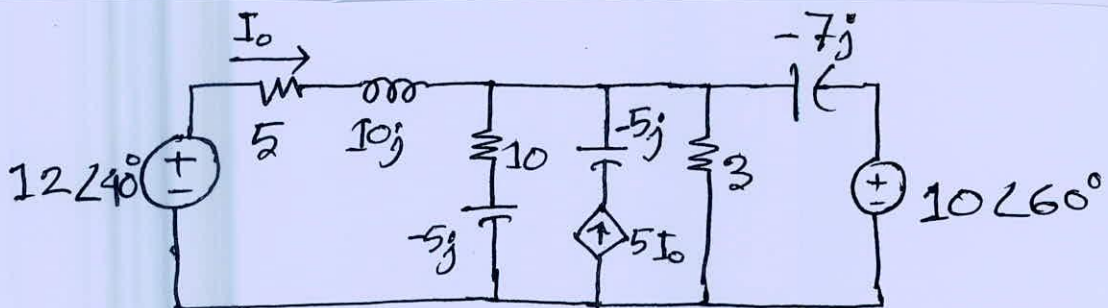## EEE 159/ME

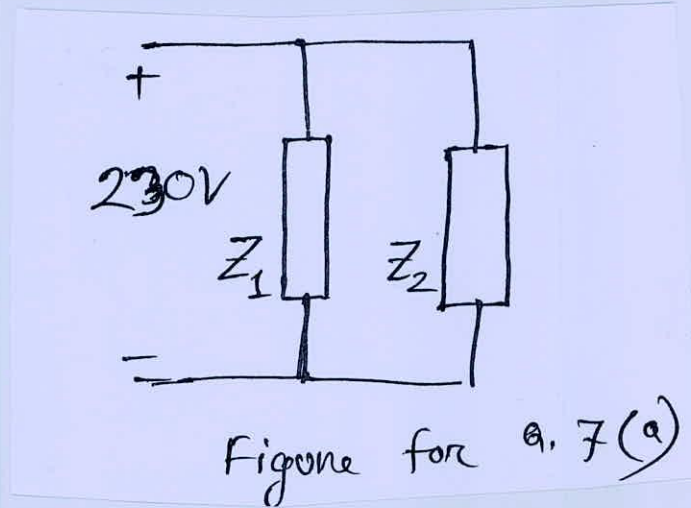7. (a) For figure Q. 7(a),   (20)

Load 1: Z_1 = A 10 KVAR, 230V(rms), 60 Hz load is operating at 0.5 power factor leading and

Load 2: Z_2 = A 15 KVA, 230V(rms), 60 Hz load is operating at 0.4 power factor leading.

Figure for Q. 7(a)

(i) What is the value of the resistance (R), capacitance (C) and inductance (L) of each of this Load Z_1 and Z_2?

(ii) What is the overall power factor of this combined load? How to change the power factor into 0.8 pf lagging.

(iii) Illustrate the change of power factor using Power factor triangle.

(b) In the circuit of Fig. for Q. 7(b), find the value of Z_L that will absorb the maximum

power and the value of the maximum power.   (15)

Figure for Q. 7(b)
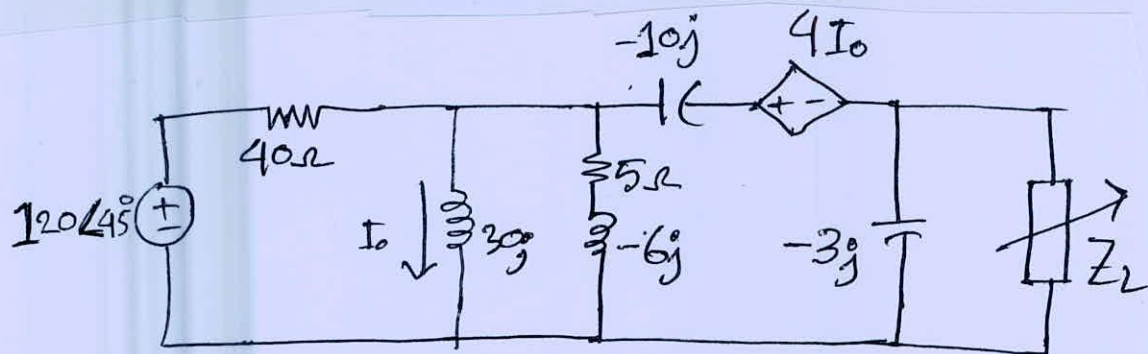
8. (a) For the circuit of Fig. for Q. 8(a),   (7+8)

(i) taking V_{L2} as reference, draw the approximate phasor diagram showing all parameter of current and voltage.

(ii) How to make the zero-phase difference between current I_1 and I_2 without changing any Resistance, Capacitance and Inductance value?
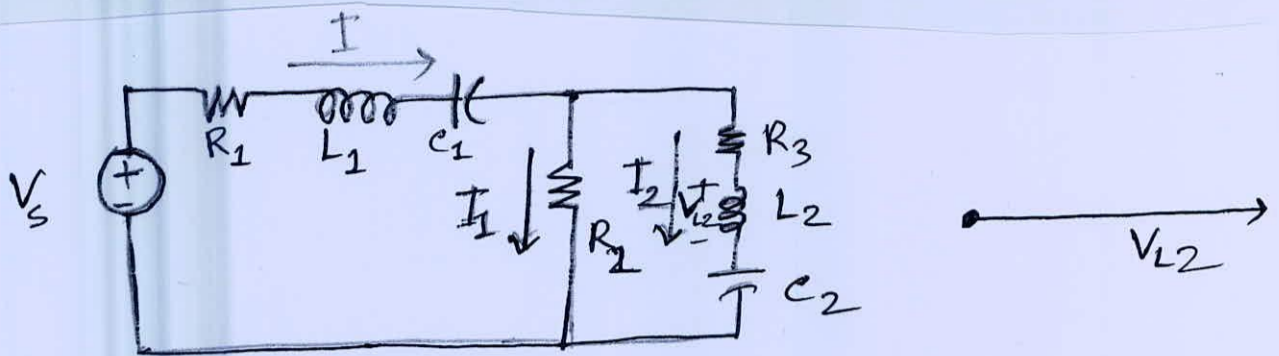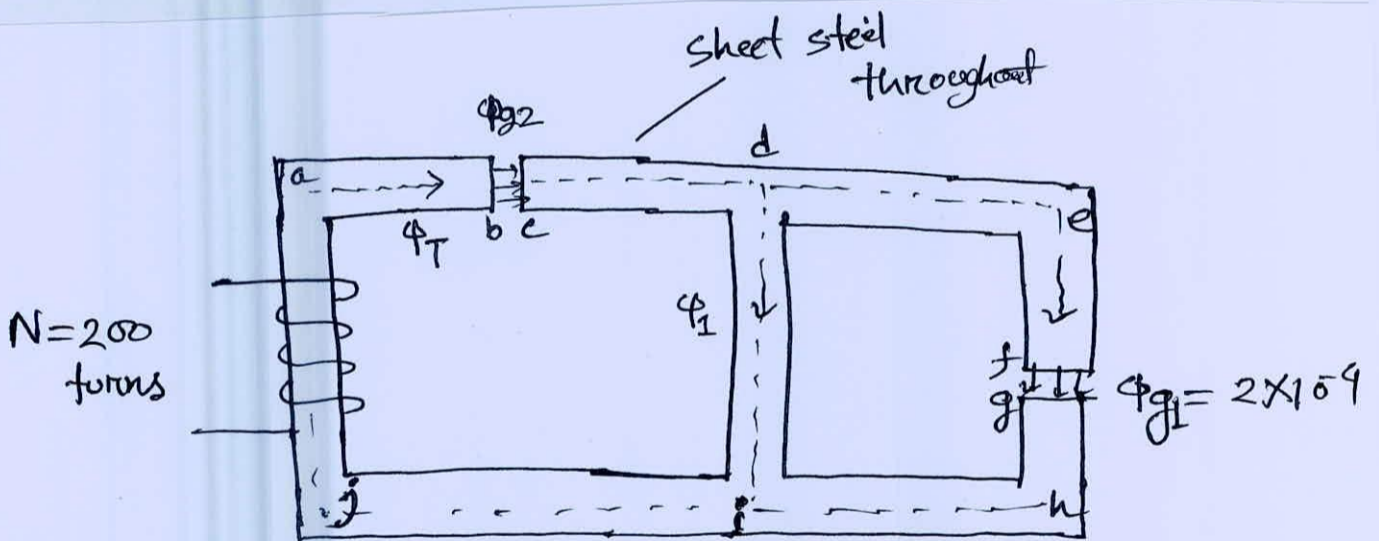
EEE 159/ME

Contd ... Q. No. 8

Figure for Q. 8(a)

(b) Determine the current I required to establish a flux of $\Phi_{g1} = 2 \times 10^{-4}$ Wb in the gap as indicated in Fig. for Q. 8(b). (20)

$l_{aj} = l_{di} = l_{eh} = 0.2m$

$l_{ad} = l_{ji} = 0.25m$

$l_{de} = l_{ih} = 0.15m$

$l_{be} = l_{fg} = 0.002$ [air gaps]

$l_{ab} = 0.1, \quad l_{ef} = 0.1$

Area throught $= 3 \times 10^{-4} m^2$

Figure for Q. 8(b)

EEE 159/ME

Contd ... Q. No. 8

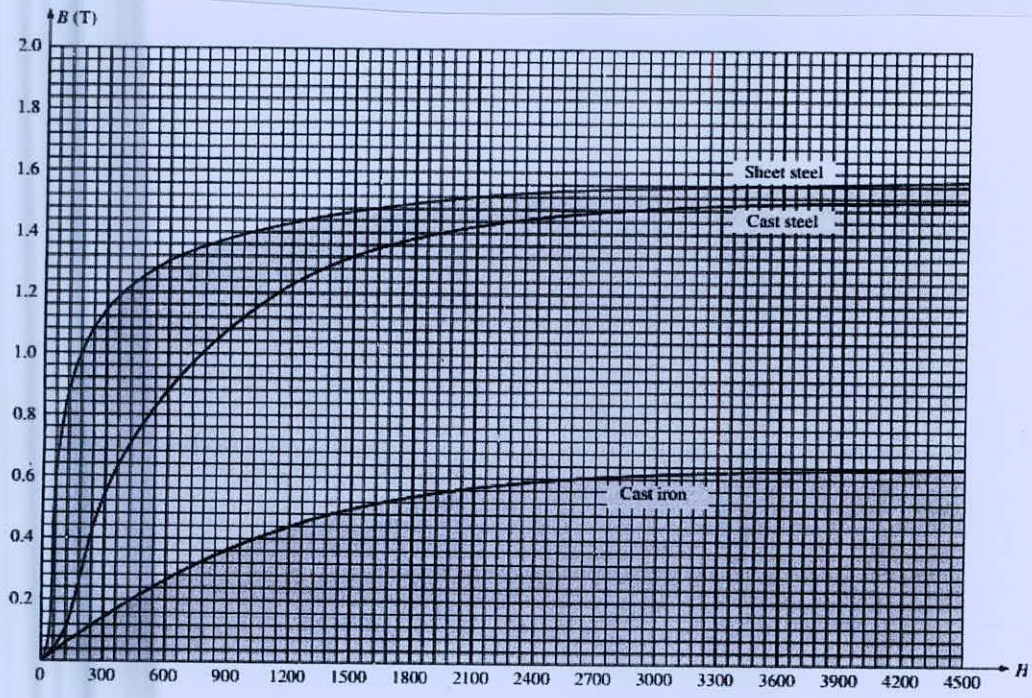*Figure for Q.8(b): Normal magnetization curve for three ferromagnetic materials*

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1   B. Sc. Engineering Examinations 2020-2021

Sub: **MATH 161** (Differential Calculus, Solid Geometry and Vectors)

Full Marks: 280   Time: 3 Hours

The figures in the margin indicate full marks

Symbols used have their usual meaning.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1.   (a) What do you understand by the derivative of a function from geometrical and physical stand point?   **(5)**

(b) Find the nth derivative of $tan^{-1}\dfrac{\sqrt{1+x^2}-1}{x}$.   **(10)**

(c) If $y = \left[x + \sqrt{1+x^2}\right]^m$; find y_n at $x = 0$.   **(15)**

(d) The radius and height of a right circular cone are measured with errors of at most 0.5% and 4.5%, respectively. Use total differential to approximate the maximum percentage error in the calculated volume. Note that the volume of a right circular cone is $\dfrac{1}{3}\pi r^2 h$. Here r and h represent the radius and height, respectively.   **(16⅔)**

2.   (a)   (i)   Evaluate $\lim\limits_{x\to 0} log_{tan^2 x} tan^2 2x$ **(10)**

(ii)   Fin the value of a and b such that $\lim\limits_{x\to 0}\dfrac{x(1+a\cos x)-b\sin x}{x^3}=1$.   **(10)**

(b) State Rolle's theorem. Discuss the applicability of Rolle's theorem for following function defined by $f(x)=\begin{cases} x^2+1, & 0\le x\le 1 \\ 3-x^2, & 1<x\le 2 \end{cases}$ on the interval [0, 2].   **(13)**

(c) Approximate the function $f(x)=\sqrt[3]{x}$ by a Taylor polynomial of a degree two about the point $x_0 = 8$. Also measure the accuracy of this approximation when x lies in the interval [7, 9] using Lagrange's form of remainder.   **(13⅔)**

3.   (a) To set up machineries on a heavy rectangular iron sheet and protect them, the sheet will be fenced in with two types of fencing. Two opposite sides facing the walls will use standard fencing selling for $30 per foot, while the remaining two sides will use heavy fencing selling for $50 a foot. What are the dimensions of the rectangular iron sheet covering maximum surface area if the available budget is $120,000.   **(16⅔)**

(b) Find the radius of curvature at (a, a) on $ay^2 = x^3$ **(14)**

(c) Establish a condition involving p, q and r so that the curve $x^{\frac{2}{3}} + y^{\frac{2}{3}} = r^{\frac{2}{3}}$ touches

the curve $\dfrac{x^2}{p^2} + \dfrac{y^2}{q^2} = 1$. **(16)**

4. (a) Find the envelop of the family of the straight lines $x\cos^3\theta + y\sin^3\theta = c$ for any

value of θ. **(15)**

(b) Find the asymptotes of the curve $x^3 - 2y^3 + xy(2x - y) + y(x - y) + 1 = 0$. **(16)**

(c) Trace the curve $r = a(\cos\theta + \sec\theta)$ showing details of the required steps. **($15\frac{2}{3}$)**

SECTION – B

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

5. (a) Prove that the straight lines whose direction cosines are given by the relations

$al + bm + cn = 0$ and $fmn + gnl + hlm = 0$ are perpendicular if $\dfrac{f}{a} + \dfrac{g}{b} + \dfrac{h}{c} = 0$ and

parallel if $\sqrt{af} \pm \sqrt{bg} \pm \sqrt{cn} = 0$. **(20)**

(b) A variable plane is at a constant distance p from the origin O and meets the axes in

A, B, C. Find the locus of the centroid of the tetrahedron $OABC$. **(13)**

(c) Find the equation of the plane passing through the points $(2,2,1)$ and $(9,3,6)$ and

perpendicular to the plane $2x + 6y + 6z = 5$. **($13\frac{2}{3}$)**

6. (a) Find the points in which the line $\dfrac{x+1}{-1} = \dfrac{y-12}{5} = \dfrac{z-7}{2}$ cuts the surface

$11x^2 - 5y^2 + z^2 = 0$. **(15)**

(b) Examine the coplanarity of the lines **($16\frac{2}{3}$)**

$\dfrac{x+5}{3} = \dfrac{y+4}{1} = \dfrac{z-7}{-2}$ and $3x + 2y + z - 2 = 0 = x - 3y + 2z - 13$.

Also find the equation of the plane in which they lie.

(c) Find the shortest distance between the lines **(15)**

$\dfrac{x-2}{2} = \dfrac{y-2}{3} = \dfrac{z-3}{4}$ and $\dfrac{x-3}{3} = \dfrac{y-3}{4} = \dfrac{z-4}{5}$

State whether the lines are coplanar or not.

MATH 171/ME

7. (a) Show that the four points whose position vectors are $3\hat{i} - 3\hat{j} + 4\hat{k}$, $6\hat{i} + 2\hat{j} + \hat{k}$, $5\hat{i} + 7\hat{j} + 3\hat{k}$ and $2\hat{i} + 2\hat{j} + 6\hat{k}$ are coplanar. **(15)**

(b) Find the volume of the parallelepiped whose adjacent edges are $\underline{c} \times \underline{a}$, $\underline{a} \times \underline{b}$ and $\underline{b} \times \underline{c}$. **(15)**

(c) Show that $\underline{a} \times (\underline{b} \times \underline{c}) = (\underline{a} \times \underline{b}) \times \underline{c}$ if and only if either $\underline{b} = 0$ or $\underline{c}$ is collinear with $\underline{a}$ or $\underline{b}$ is perpendicular to both $\underline{a}$ and $\underline{c}$. **(16⅔)**

8. (a) Find a set of vectors reciprocal to the set $2\hat{i} + 3\hat{j} - \hat{k}$, $\hat{i} - \hat{j} - 2\hat{k}$ and $-\hat{i} + 2\hat{j} + 2\hat{k}$. **(18)**

(b) A vector $\underline{x}$ satisfies the equation $\underline{x} \times \underline{b} = \underline{c} \times \underline{b}$ and $\underline{x} . \underline{a} = 0$. Prove that **(10⅔)**

$$\underline{x} = \underline{c} - \frac{(\underline{a} . \underline{c})\underline{b}}{\underline{a} . \underline{b}}.$$

(c) A force $\underline{F} = 4\hat{i} - \hat{j} + 3\hat{k}$ is applied at the point P (3, 1, 2). The moment of this force about the point A (t, 1, 2t) is $6\hat{i} + 9\hat{j} - 5\hat{k}$. Find the value of t. **(18)**