Bangladesh University of Engineering and Technology, Dhaka

L1/T1 B.Sc. Engineering Examinations, January 2020

Subject: Chem 111 (Inorganic Chemistry)

Full Marks: 180 Time: 2 hours

Figure in the margin indicate the full marks

Use separate scripts for each section and upload in the LMS system separately

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Section A

(There are **FOUR** questions in the section. Answer any **THREE**)

1a. Draw the Lewis structures and predict the geometry of the following compounds using VSEPR model: PCl_4^+, ClF_3, SF_4 — 6

b. In molecular orbitals diagram, the energy of $\pi 2p$ orbital is lower than that of $\sigma 2p$ for B_2, C_2, and N_2. For O_2, F_2, and Ne_2, the energy of $\sigma 2p$ orbital is lower than the $\pi 2p$. Why does this happen? — 14

c. Show the bond formation of CO using Molecular Orbital Theory. — 10

2a. Draw the orbital energy levels in a single electron system (like H) and a multi-electron system. Why is the orbital energy levels pattern different in these two systems? Discuss briefly. — 12

b. Calculate the wavelength (in nanometers) of a photon emitted by a hydrogen atom when its electron drops from the n = 5 state to the n = 2 state. — 12

c. A sample of magnesium is found to contain 78.70% of ^{24}Mg atoms (mass 23.98 amu), 10.13% of ^{25}Mg atoms (mass 24.99 amu), and 11.17% of ^{26}Mg atoms (mass 25.98 amu). Calculate the average mass of a Mg atom. — 6

3a. Calculate Z_{eff} for: (i) a 4p electron of Ag (Z = 47) (ii) 3d electron of Xe (Z = 54) (iii) 5d electron of Tungsten (Z = 74) — 12

b. Within any period, values of first ionization energy tend to increase with atomic number, except for small drops at the group IIIA and VIA elements. Explain — 12

c. Arrange the following in order of increasing first ionization energy: — 6

i. Na, Cl, Al, S, and Cs ii. F, K, P, Ca, and Ne

4a. Explain the bond formation of N_2 and N_2^- using MOT. Which one will be more stable? Why? — 12

b. For the isolation of inert gas mixture from dry air, nitrogen, oxygen, moisture, and carbon dioxide of the air are removed by some reactions. Write down the reactions — 8

c. Using Valence Bond Theory, show and discuss the formation of SF_6 molecule. — 10

Section B

(There are **FOUR** questions in the section. Answer any **THREE**)

5a. Why is the Arrhenius acid-base definition too limited? Which acid/base theory or theories could be applied to explain the behavior of SO_2 in an aqueous solution? 10

b. Use the Bronsted-Lowry theory to explain the reactions which happen when 10
   (i) hydrogen chloride gas dissolves in water;
   (ii) hydrogen chloride gas and ammonia gas react

c. Justify the following statement "BF_3 is an acid but NH_3 is a base." 10
Identify the Lewis base in this reaction, $KH + H_2O \rightarrow KOH + H_2$

6a. Give the equation for the dissolution of SiO_2 glass by HF and interpret the reaction in terms of Lewis and Brønsted acid–base concepts. How is the adduct formation explained by hard and soft acid-base theory? 10

b. Explain (i) coordination of thiocyanate to Hg^{2+} (ii) AgF is the most soluble silver halide, but LiF is the least soluble among the lithium halides 10

c. "Hard acids tend to bind to hard bases, and soft acids tend to bind to soft bases" justify with the help of appropriate examples 10

7a. What are the advantages of having a metal ion at the active site of an enzyme? Give chemical names for the following (i) $[Cu(NH_3)_4]^{2+}$ (ii) $[PtCl_4]^{2-}$ (iii) $[Mn(CN)_6]^{4-}$ 10

b. Give systematic names for the following formulas (i) $[Cr(en)_3](ClO4)_3$ (ii) $[Cr(NH_3)_6][Cr(CN)_6]$. Sketch structures of all isomers of $M(BB)_3$, in which BB is a bidentate symmetrical ligand, and identify the type of isomerism among them. 10

c. Solutions of the complexes $[Co(NH_3)_6]^{2+}$, $[Co(OH_2)_6]^{2+}$ (both octahedral), and $[CoCl_4]^{2-}$ are colored. One is pink, another is yellow, and the third is blue. Considering the spectrochemical series and the relative magnitudes of Δ_T and $\Delta_{Octahedral}$, assign each color to one of the complexes. 10

8a. For each complex, predict its hybridization, structure, the number of unpaired electrons present and whether it is high spin or low spin (i) $[TiCl_6]^{3-}$ (ii) $[CoCl_4]^{2-}$. 10

b. How can CFT explain the color of a transition-metal complex? Do strong-field ligands favor a tetrahedral or a square planar structure? 10

c. Fe(II) forms the complex ion $[Fe(OH)_4]^{2-}$ through equilibrium reactions in which hydroxide replaces water in a stepwise manner. If $\log K_1 = 5.56$, $\log K_2 = 4.21$, $\log K_3 = -0.10$, and $\log K_4 = -1.09$, what is K_f? Write the equilibrium equation that corresponds to each stepwise equilibrium constant. Do you expect the $[Fe(OH)_4]^{2-}$ complex to be stable? 10

L-1/T-1/ChE Date: 14/01/2021

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

B. Sc. Engineering Examinations January 2020

Sub: **PHY 111** (Physical Optics, Waves & Oscillations and Heat & Thermodynamics)

Full Marks: 180 Time: 2 Hours

The figures in the margin indicate full marks. Symbols have their usual meaning.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION-A

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

1. (a) Two reversible engines A and B working between the same two temperature limits T_1 (higher) and T_2 (lower). Prove that their efficiencies are equal. [20]

   (b) 7500 Joule of heat energy is absorbed by a heat engine from the hot reservoir at 600K and 6000 Joule is released into the cold reservoir at 300K. What is the maximum efficiency of this heat engine? [10]

2. (a) Establish a relationship between the degrees of freedom and the ratio of specific heats at constant volume and constant pressure. [20]

   (b) Calculate the total rotational kinetic energy of all the molecules in one mole of air at 27°C. Given R=8.314 J/mole-K and $N=6.023\times10^{23}$ mol^{-1}. [10]

3. (a) Show that the entropy remains constant in a reversible adiabatic process. [20]

   (b) Calculate the latent heat of ice in cal/g, given that change of pressure of 1 atmosphere changes the melting point of ice by 0.0074°C and when 1 g of ice melts volume changes by 0.0907 cc. [10]

4. (a) Which phenomenon helps to establish that light waves are transverse waves? Explain this phenomenon when light waves allow to pass through a tourmaline crystal. Draw a diagram showing plane of vibration and plane of polarization in support of that phenomenon. [14]

   (b) Mention the name of a negative crystal and a positive crystal which are used as quarter wave plate and half wave plate. Derive the equation for the thickness of such crystals when plane polarized light allows to passes through them. [16]

SECTION-B

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

5. (a) Based on Huygen's principle and energy transfer analogy by light waves, explain why interference patterns are not standing waves? Draw the schematic diagram of Young's double-slit experiment based on Huygen's principle and clearly indicates the terms involved. Write down the equations for the positions of bright fringes and dark fringes considering $L >> d$ and $\lambda << d$. [20]

   (b) Suppose you are passing light from a He-Ne laser through two slits separated by 0.015 mm and find that the third bright line on a screen is formed at an angle of 10.55° relative to the incident beam.

   (i) What is the wavelength of the light?

   (ii) What is the highest-order constructive interference possible with the system? [10]

6. (a) Diffraction grating and prism both are used for spectral analysis. What are the differences between these two when white light passes through them? Draw the diagram of transmission grating and reflection grating and briefly explain their working mechanism with light. [22]

   (b) A diffraction grating having 1650 lines per cm is used at normal incidence. Calculate the dispersive power of the grating in the second order in the 500 nm wavelength region. [8]

7. (a) A particle executing damped harmonic motion is subjected to an external periodic force. Establish the differential equation for the motion of the particle, explain the physical meaning of each term and each constant in the equation. [18]

   (b) The expression of displacement of forced oscillation is given by

$$x_m = \frac{F_{ext} \sin \omega' t}{[m^2(\omega'^2 - \omega^2)^2 + b^2\omega'^2]^{1/2}}$$

   where F_{ext} is the magnitude of the external force, ω' → Driver's frequency, ω → Driven frequency, b→Damping constant. Show that velocity of the oscillating system is $V_{max} = F_{ext}/b$ at resonance. [12]

8. (a) Discuss the formation of stationary wave due to reflection at a rigid boundary. [15]

   (b) The fixed supports of a nylon guitar string are 90 cm apart. The string is oscillating as a three loop standing wave.

   (i) Calculate the wave length of the travelling waves whose superposition gives the standing wave.

   (ii) Determine the positions of antinodes. [15]

L-1/T-1/ChE **Date:11/01/2021**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, BUET

L-1/T-1 B.Sc. Engineering Examinations **2019-2020**

Sub: **ME 141** (Engineering Mechanics)

Full Marks: 180 Time: 2 Hours

The figures in the margin indicate full marks.

Symbols used have their usual meaning and interpretation.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION-A

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

1. (a) Two planes *A* and *B*, are flying at the same altitude as shown in Fig. for Q. 1(a). If their velocities are v_A = 500 km/h and v_B = 700 km/h such that the angle between their straight-line courses is 60°, determine the velocity of plane *B* relative to plane *A*. **(8)**

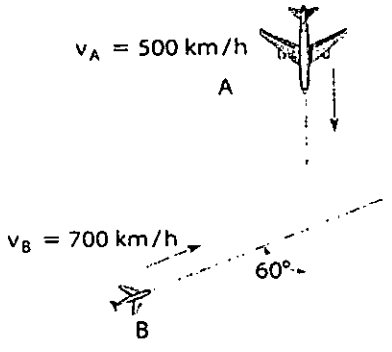


Fig. for Q. 1(a)

(b) Collar *A* starts from rest at t = 0 as shown in Fig. for Q. 1(b) and moves downward with a constant acceleration of 5 in./s². Collar *B* moves upward with a constant acceleration, and its initial velocity is 7 in./s. Knowing that collar *B* moves through 22 in. between t = 0 and t = 2.5 s, determine (*i*) the accelerations of collar *B* and block *C*, (*ii*) the time at which the velocity of block *C* is zero. **(22)**

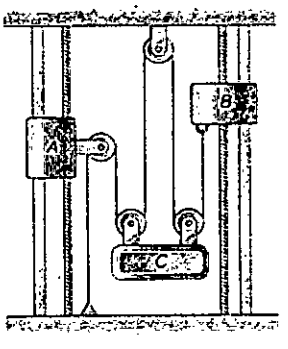


Fig. for Q. 1(b)

2. (a) A single wire *ACB* passes through a ring at *C* attached to a sphere which revolves at a constant speed '*v*' in the horizontal circle as shown in Fig. for Q. 2(a). Knowing that the tension is the same in both portions of the wire, determine the speed '*v*'. **(6)**

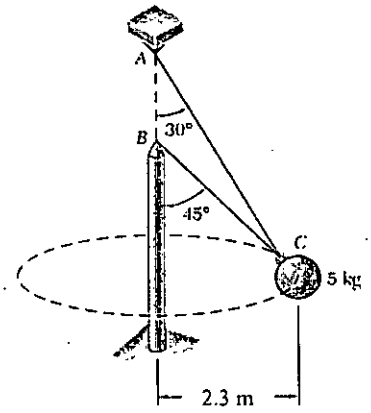


Fig. for Q. 2(a)

(b) Block *B* of mass 5-kg rests as shown in Fig. for Q. 2(b) on the upper surface of a 13-kg wedge *A*. Knowing that the system is released from rest and neglecting friction, determine the acceleration of *B*. **(24)**

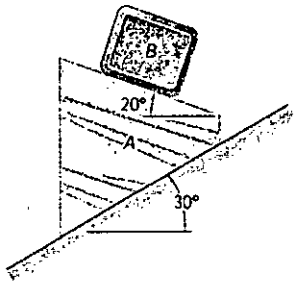


Fig. for Q. 2(b)

3. (a) Water flows from a drain spout with an initial velocity of 0.75 m/s at an angle of 15° with the horizontal, as shown in Fig. for Q. No. 3(a). Determine the range of values of the distance '*d*' for which the water will enter the trough *BC*. **(13)**

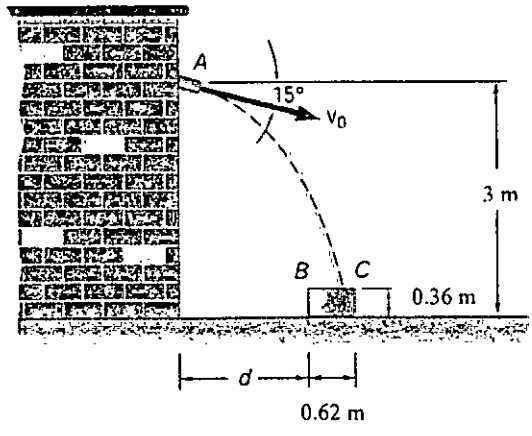


Fig. for Q. 3(a)

(b) A 10-kg collar travels down a smooth slope as shown in Fig. for Q. 3(b). If at S_1 its speed is 20 m/s, determine its speed when it gets to S_2. The spring remains horizontal. It has an original length of 8 m and spring constant k = 40 N/m. **(17)**

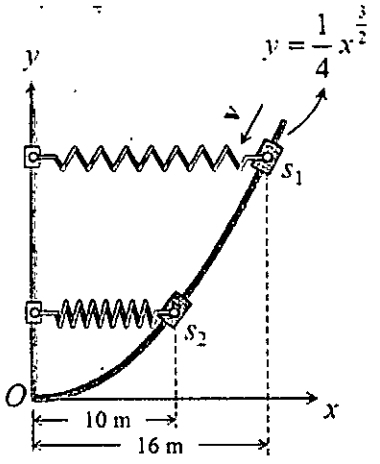


Fig. for Q. 3(b)

4. The 12-kg block has an initial speed of 4 m/s when it is midway between springs A and B as shown in Fig. for Q. 4. After striking spring B, it rebounds and slides across the horizontal plane toward spring A. If the coefficient of kinetic friction between the plane and block is μ_k = 0.4, determine the total distance traveled by the block before it comes to rest. **(30)**

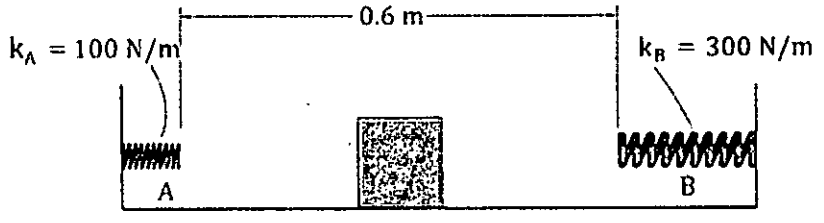


Fig. for Q. 4

SECTION-B

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

5. (a) A 12 kN vertical force is applied to boom OA that is supported by the ball-and-socket joint at O. The 6-m long uniform boom weighs 3 kN and is suspended in the horizontal position by two cables AB and CD as shown in Fig. for Q. 5(a). Determine the tensions in the cables. **(18)**

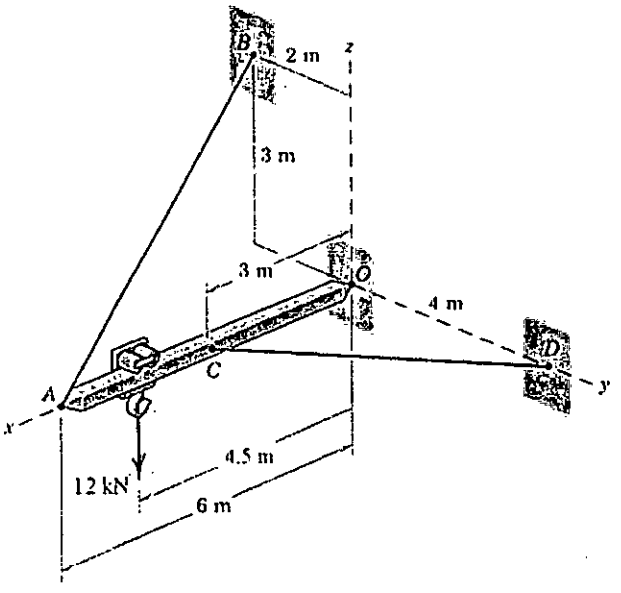


Fig. for Q. 5(a)

(b) The tension force T = 200 N is applied on the plate at point C as shown in Fig. for Q. 5(b). Use vector cross product to determine the moment of the tension about point A. **(12)**

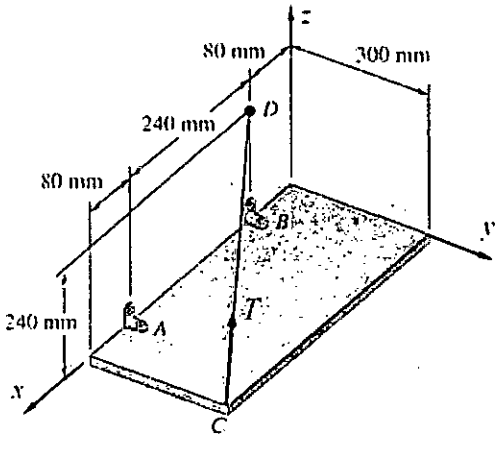


Fig. for Q. 5(b)

6. Determine the reactions at supports J and D and the forces in members BC, CH, and HG of the loaded truss composed of equilateral triangles as shown in Fig. for Q. 6. **(30)**

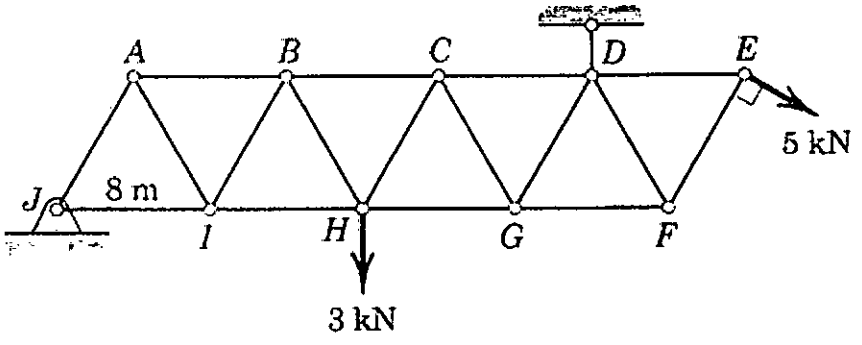


Fig. for Q. 6

7. The loaded frame supported at pin A and roller D consists of three bars that are pin connected as shown in Fig. for Q. 7. Determine the magnitude of each connection force at pins B, C, and E. **(30)**

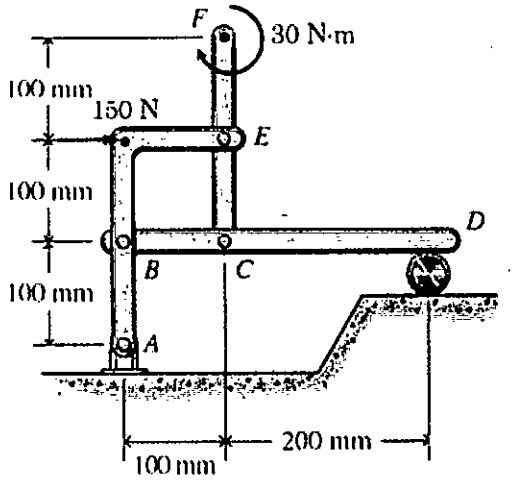


Fig. for Q. 7

8. (a) Determine the x and y-coordinates of the centroid of the shaded area shown in Fig. for Q. 8(a). **(18)**

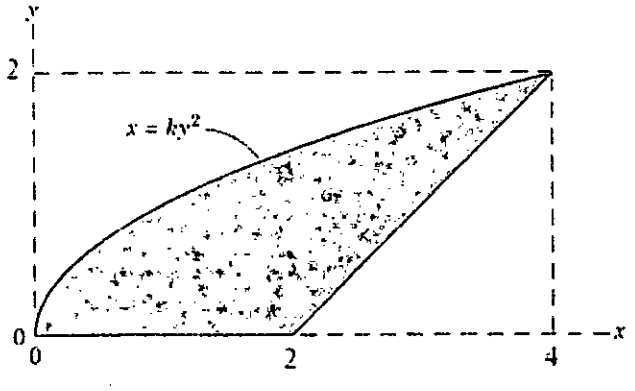


Fig. for Q. 8(a)

(b) Determine the moment of inertia of the cross section of the beam about the y_0 - axis that pass through the centroid of the L-shaped area as shown in Fig. for Q. 8(b). **(12)**

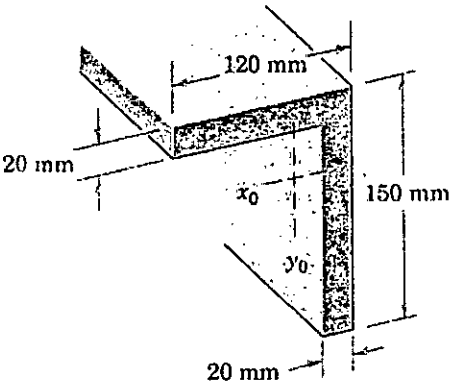


Fig. for Q. 8(b)

L-1/T-1/CHE Date:-18/01/2021

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1 B. Sc. Engineering Examinations 2018-2019

Sub: **MATH 121 (Differential Calculus and Coordinate Geometry)**

Full Marks: 180 Time: 2 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

Symbols used have their usual meaning.

SECTION-A

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

1. **(a)** A function $f(x)$ is defined as follows: **(20)**

$$f(x)=\begin{cases} x^2;\ when\ 0\le x<\frac{1}{2} \\ 0;\ when\ x=\frac{1}{2} \\ x+3;\ when\ \frac{1}{2}<x\le 1 \end{cases}$$

Discuss the continuity and differentiability of the function at $x=0$ and also represent them graphically.

(b) If $x=\tan(\ln y)$, then show that **(10)**

$$(1+x^2)y_{n+2}+(2nx+2x-1)y_{n+1}+n(n+1)y_n=0.$$

2. **(a)** Evaluate the value of: **(20)**

i). $\lim_{x\to\infty} 2^x \sin\left(\frac{a}{2^x}\right)$ *ii*). $\lim_{x\to 0}\left(\frac{1}{x}-\frac{\ln(1+x)}{x^2}\right)$.

(b) Verify Lagrange's Mean -Value Theorem for $f(x)=x-3\sin x$, in $[-\pi,\pi]$. **(10)**

3. **(a)** If $z=x+f(u)$ and $u=xy$ then show that, $x\frac{\partial z}{\partial x}-y\frac{\partial z}{\partial x}=x$. **(15)**

(b) Expand $\ln(\sin x)$ in power of $(x-a)$ with Lagrange's form of remainder after n- terms. **(15)**

4. **(a)** A rectangular sheet of thin cardboard is $80cm$ by $50cm$. A square of x is cut away from each corner of the sheet which is then folded to form an open rectangular box of volume $y\ cm^3$. Show that $y=4000x-260x^2+4x^3$. Also find out the maximum volume of the box. **(20)**

(b) Find the equation of tangent and normal to the curve $y(x-2)(x-3)-x+7=0$ at the point of x-interception. **(10)**

SECTION-B

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

5. Transform the equation $14x^2 - 4xy + 11y^2 - 44x - 58y + 71 = 0$ in rectangular coordinates using suitable translation and rotation of axes so as to remove the terms in x, y and xy. **(30)**

6. (a) If $ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0$ represents a pair of straight lines, prove that the area of the triangle formed by their bisectors and the x-axis is **(20)**

$$\frac{\sqrt{(a-b)^2+4h^2}}{2h}\left(\frac{ca-g^2}{ab-h^2}\right)$$

(b) Prove that the pair of lines joining the origin to the points of intersection of the curve $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ by the line $lx + my + n = 0$ are coincident if $a^2l^2 + b^2m^2 = n^2$. **(10)**

7. (a) The equation of a chord of the circle $x^2 + y^2 + 4x - 6y = 0$ is given by $x + 2y = 0$. Find the equation of the circle described on this chord as diameter. In addition, find the equations of their common normal. **(15)**

(b) Find the equation of the circle which passes through $(3, -2)$ and co-axial with each of the circles $x^2 + y^2 + 4x - 3y - 7 = 0$ and $x^2 + y^2 + 3x - 2y - 10 = 0$. **(15)**

8. (a) Prove that the locus of the middle points of the normal chords of the parabola $y^2 = 4ax$ is $\frac{4a^3}{y^2} + \frac{y^2}{2a} = x - 2a$. **(15)**

(b) Prove that the locus of the middle points of the portions of the tangents to the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ included between the axes is the curve $\frac{a^2}{x^2} + \frac{b^2}{y^2} = 4$. **(15)**

L-1/T-1/ChE **Date: 25/01/2021**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-I B.Sc. Engineering Examination 2018-19

Sub: **EEE 155** (Electrical Engineering Fundamentals)

Full Marks: 180 Time 2 Hours

The Figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

There are 7 page(s) in this question paper.

SECTION – A

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

All the symbols have their usual meanings

Assume reasonable values for missing data.

1. (a) Two motor loads are connected in parallel. Motor 1 takes 250 A (rms) at 0.8 lagging power factor while motor 2 absorbs 50 KW at 0.5 leading power factor. What is the power factor of the combined load? What is the total current absorbed by the two motors? Assume the line voltage is 220 V (rms). (15)

   (b) Find out the power factor of the circuit shown in Fig. for Q. No. 1(b). To what value must the 10 μF capacitor be changed to result in the overall power factor 0.95 lagging? (15)

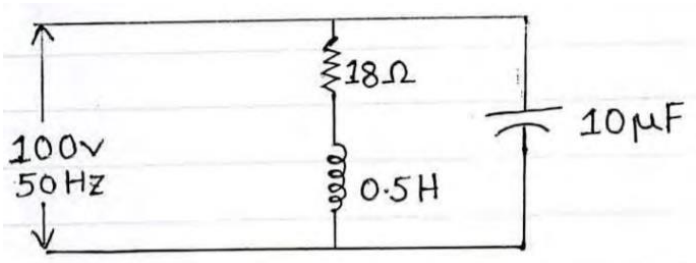


Fig. for Q. No. 1(b)

2. (a) Find the effective value of the voltage having the wave shape as shown in Fig. for Q. No. 2(a). (20)

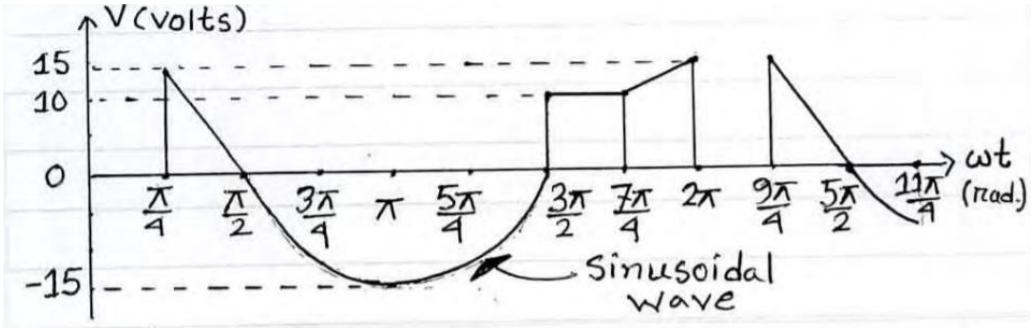


Fig. for Q. No. 2(a)

(b) A resistance and a reactance are series connected. Voltage across the resistance, V_{res}= 8 sin(l20πt) and across reactance, V_{react}= 6 cos(l20πt). From the information, can you tell whether the reactive element is an inductor or a capacitor? If not, what more information do you need to answer that question? (10)

3. (a) For the circuit shown in Fig. for Q. No. 3(a), the voltage across the resistor of load 3 is 10 V. Consider the current through load3 as the reference and draw the phasor diagram indicating all voltages. (20)

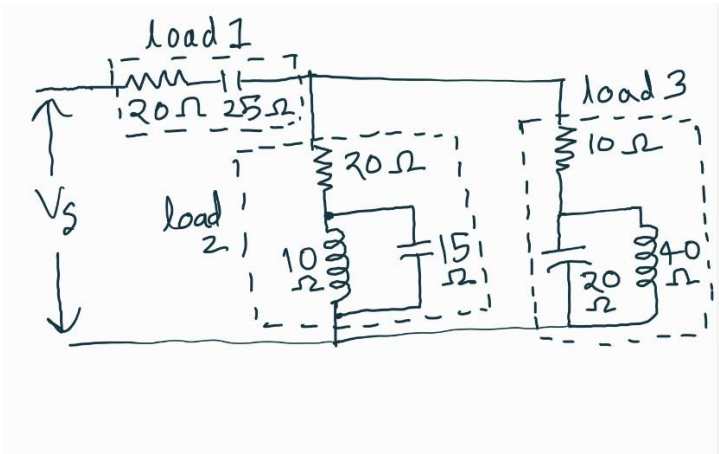


Fig. for Q. No. 3(a)

(b) In the circuit shown in Fig. for Q. No. 3(b), V_1 = 12 sin(ωt) V, the current flowing through the inductor is -j2.4 A and the current flowing through the RC branch is 3.6∠45° A. The product of values of L and C is 10^{-9}. Find the operating frequency (ω) of the voltage source at this condition. (10)

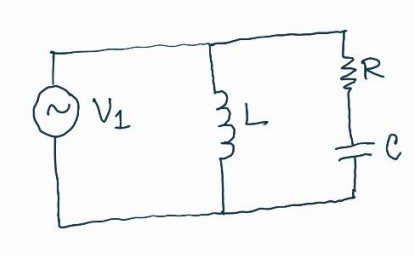


Fig. for Q. No. 3(b)

4. (a) Find the value of I required to establish a magnetic flux, $\varphi_2 = 1 \times 10^{-4}$ wb as shown in Fig. for Q. No. 4(a). The sheet steel is laminated with a Stacking Factor of 0.9. Also consider fringing effect. (25)

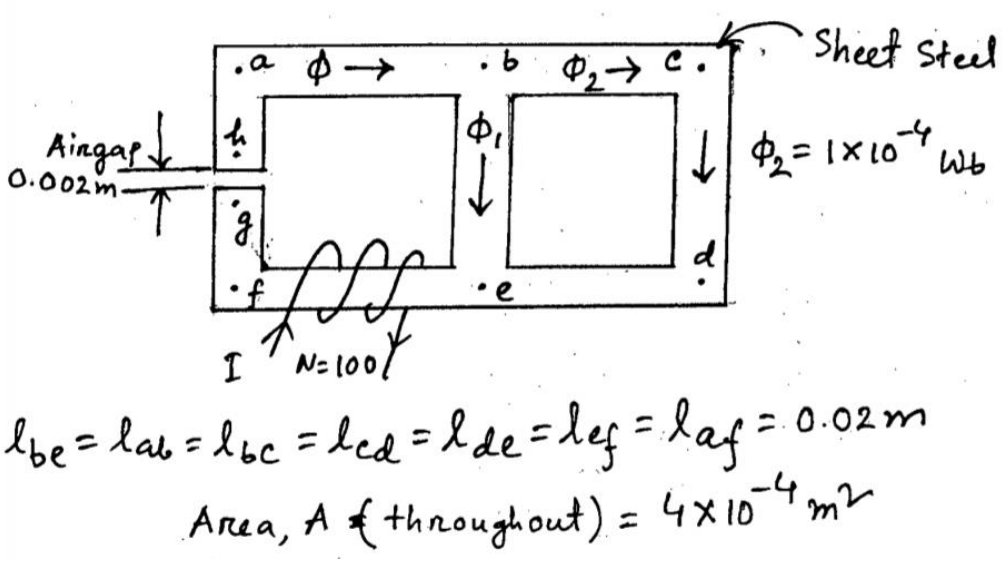
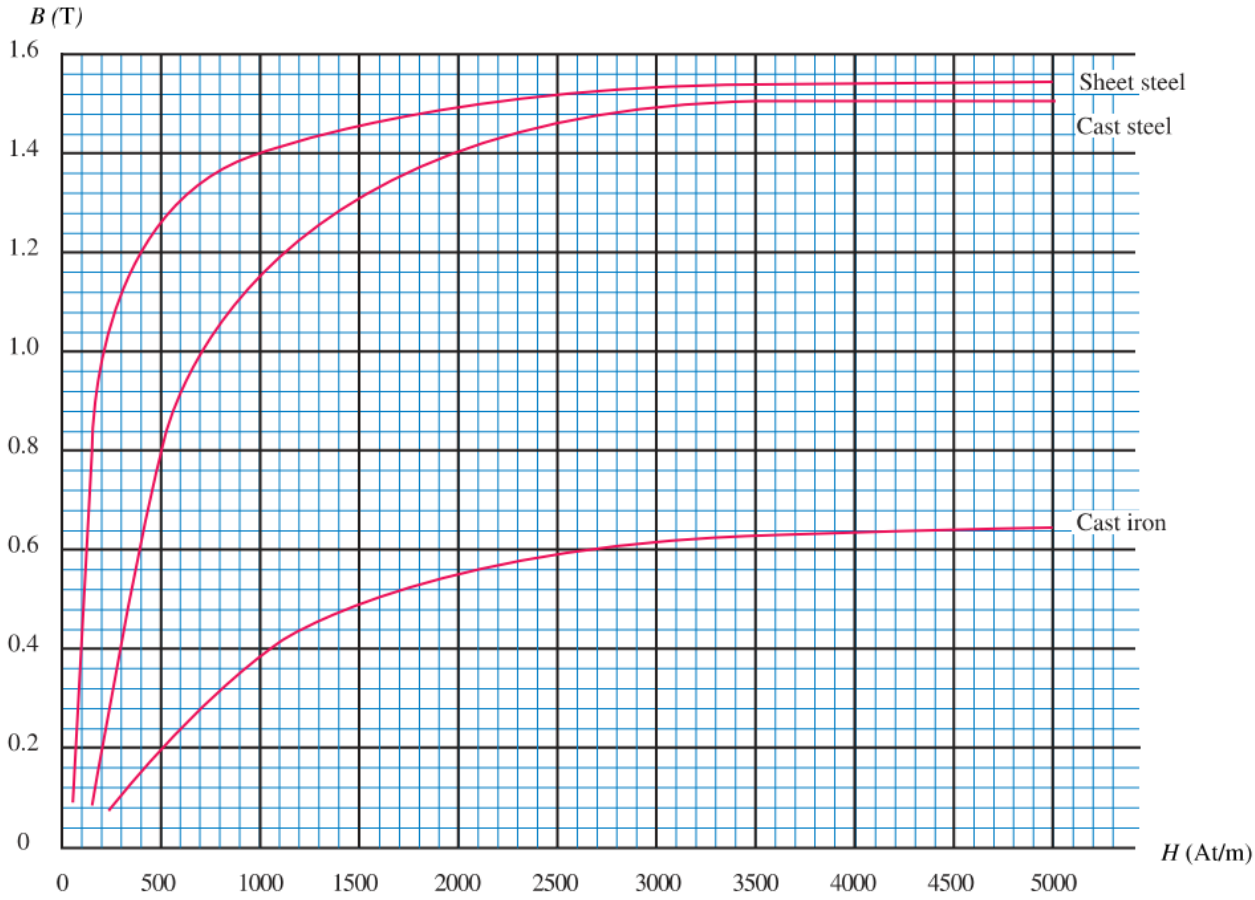


Fig. for Q. No. 4(a)

(b) Refer to the question in 4(a). "To increase the air gap flux twofold, the value of I has to be doubled." - Do you agree? Why or why not? (05)



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) The voltage and current at the terminals of the circuit element are shown below. Sketch the power vs time plot for $0 \leq t \leq 10$s. Also calculate the energy delivered to the circuit at t = 1, 6 and 10s. (15)

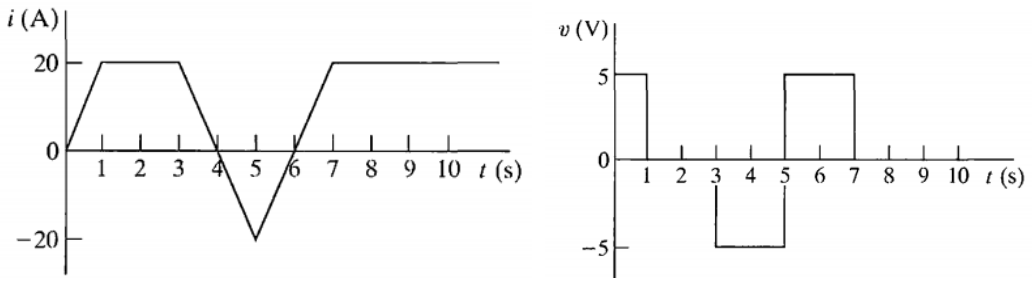


Fig 5(a)

(b) Find the equivalent resistance at a-b terminal. (15)

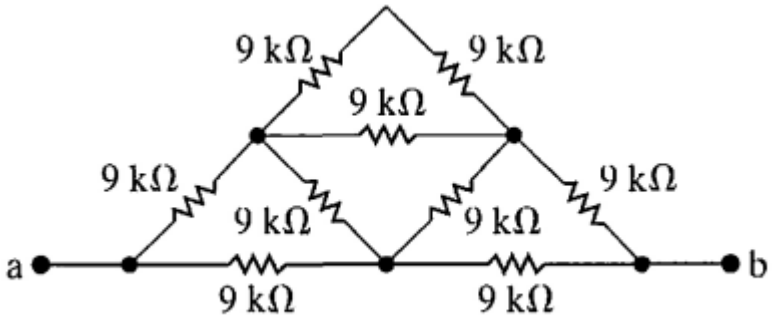


Fig 5(b)

6. (a) What is supernode? Find the voltages at the three non-reference nodes in the circuit below using nodal analysis. (20)

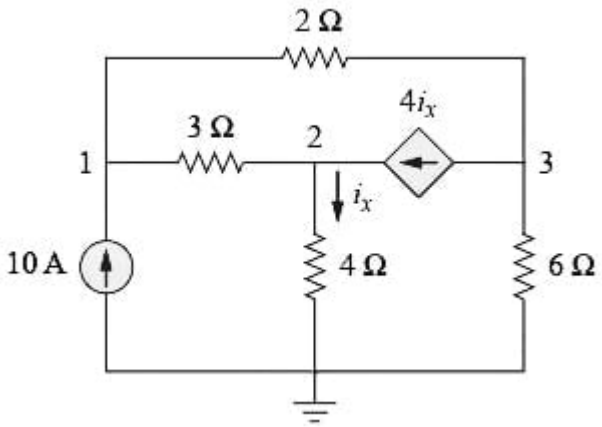


Fig 6(a)

(b) Use the mesh-current method to find the power dissipated in the 2Ω resistor in the circuit. (10)

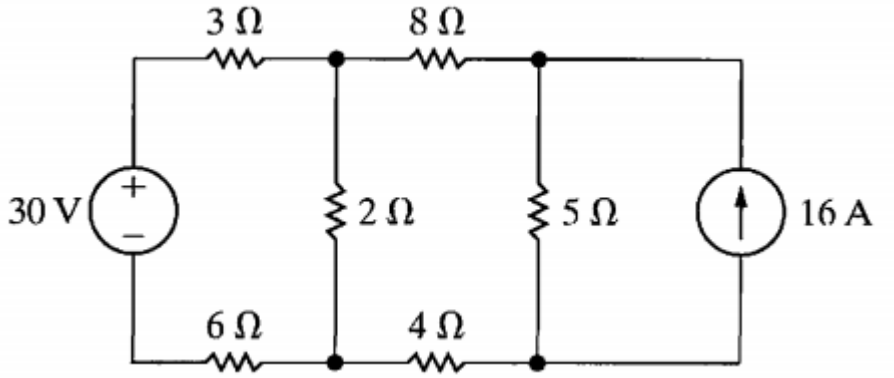


Fig 6(b)

7. (a) Use a series of source transformations to find the voltage v in the circuit shown. (15)

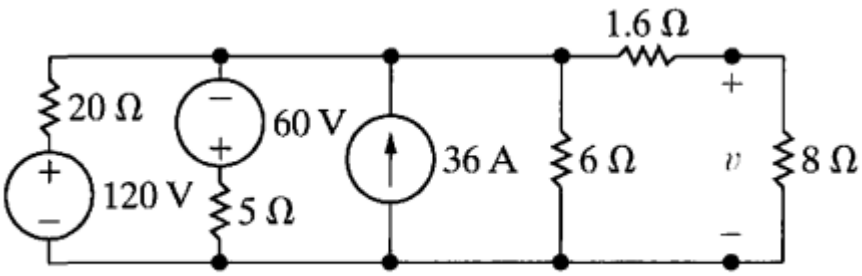


Fig 7(a)

(b) Find R_L for maximum power transfer and find the maximum power also. (15)

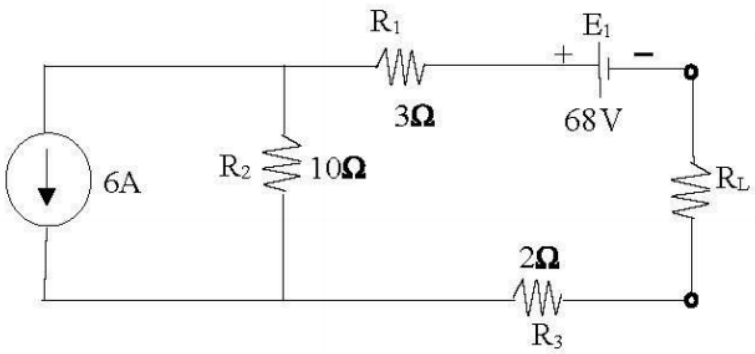


Fig 7(b)

8 (a) Determine v_0 in the circuit using the superposition principle. (20)

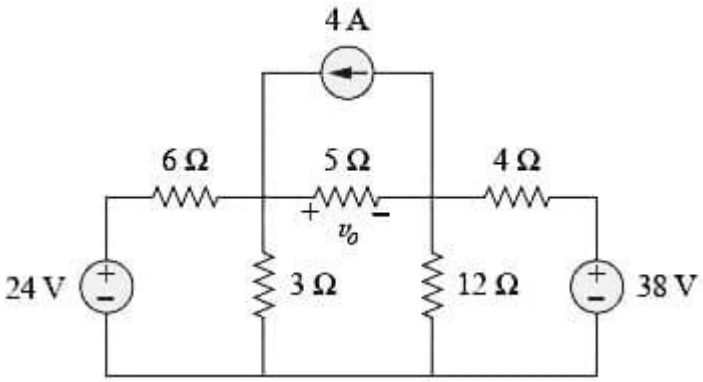


Fig 8(a)

(b) Explain and derive the maximum power transfer theorem. (10)