L-1/T-2/WRE

Date: 31/03/2019

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2017-2018

Sub: MATH 133 (Matrix and Three Dimensional Co-ordinate Geometry)

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.

Symbols used have their usual meaning.

1. (a) Using only elementary row transformations, find the inverse of A when

\[
A = \begin{bmatrix}
1 & 2 & 3 & 4 \\
2 & 3 & 4 & 5 \\
3 & 4 & 5 & 7 \\
4 & 5 & 5 & 7 \\
\end{bmatrix}
\]

(b) Reduce \[ A = \begin{bmatrix} 1 & -2 & 1 & 3 \\
4 & -1 & 5 & 8 \\
2 & 3 & 3 & 2 \end{bmatrix} \] to the normal form \( B \) and compute the matrices \( P \) and \( Q \) such that \( P A Q = B \), where \( A \) and \( B \) are equivalent matrices.

2. (a) Express the following system of linear equations in echelon form and then solve:

\[
\begin{align*}
x_1 - x_2 + 2x_3 + x_4 &= 0 \\
-x_1 + 3x_2 + 2x_4 &= 2 \\
2x_1 + x_2 - x_4 &= 1 \\
2x_1 + 2x_2 + x_3 + 3x_4 &= 14
\end{align*}
\]

(b) For what values of \( k \), the following system of linear equations have a solution and solve them completely in each case:

\[
\begin{align*}
x + y + z &= 1 \\
x + 2y + 4z &= k \\
x + 4y + 10z &= k'
\end{align*}
\]

(c) Find the basis for the eigen spaces of \( A \) where

\[
A = \begin{bmatrix} 0 & 0 & -2 \\
1 & 2 & 1 \\
1 & 0 & 3 \end{bmatrix}
\]

3. (a) Define quadratic form and explain its matrix representation. Reduce the quadratic form \( q = x_1^2 + 2x_1^2 - 2x_1^2 + 4x_1x_2 + 6x_3x_4 \) to the canonical form and hence find the rank, index and signature of the form.

(b) State Cayley-Hamilton theorem and using this theorem, find \( A^4 \), when

\[
A = \begin{bmatrix} 1 & 2 & 2 \\
3 & 1 & 0 \\
1 & 1 & 1 \end{bmatrix}
\]

Using above also find \( A^3 \) and \( A^5 \).
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4. (a) Find all eigenvalues and corresponding eigenvectors for the matrix:
\[
A = \begin{bmatrix}
4 & 6 & 6 \\
1 & 3 & 2 \\
-1 & -4 & -3
\end{bmatrix}
\]
Also find the matrix \( P \) that diagonalizes \( A \) and determine \( P^{-1}AP \).

(b) Find the minimum polynomial \( m(\lambda) \) for the matrix \( A \) where
\[
A = \begin{bmatrix}
3 & 1 & 0 & 0 \\
0 & 3 & 0 & 0 \\
0 & 0 & 2 & 1 \\
0 & 0 & 1 & 2
\end{bmatrix}
\]

SECTION - B

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

5. (a) if \( l_1, m_1, n_1 \) and \( l_2, m_2, n_2 \) are the direction cosines of two mutually perpendicular
lines, show that the direction cosines of the line perpendicular to them both are
\[
m_1n_2 - m_2n_1, \quad n_1l_2 - n_2l_1, \quad l_1m_2 - l_2m_1.
\]

(b) Prove that the angle between two diagonals of a cube is \( \cos^{-1} \left( \frac{1}{3} \right) \).

(c) Show that the two lines whose direction cosines are given by the
relations \( al + bm + cn = 0 \) and \( ul^2 + vm^2 + wn^2 = 0 \) are perpendicular if
\[
a'(v+w)+b'(w+u)+c'(u+v)=0 \quad \text{and parallel if} \quad \frac{a'^2}{u} + \frac{b'^2}{v} + \frac{c'^2}{w} = 0.
\]

6. (a) Find the equation of the plane through the intersection of the planes
\( x+2y+3z-4=0 \) and \( 2x+y-z+5=0 \) and perpendicular to the plane
\( 5x+3y+6z+8=0 \).

(b) Find the plane that bisects the acute angle between the planes \( 2x-y+2z+3=0 \)
and \( 3x-2y+6z+8=0 \).

(c) A variable plane is at a constant distance \( p \) from the origin and meets the axes in \( A, B \) and \( C \). Show that the locus of the centroid of the tetrahedron \( OABC \) is
\[
x^2+y^2+z^2=16p^2.
\]
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7. (a) Find the length of the shortest distance between the lines \( \frac{x-3}{1} = \frac{y-5}{-2} = \frac{z-7}{1} \) and
\( \frac{x+1}{7} = \frac{y+1}{-6} = \frac{z+1}{1} \). Find also its equation and the points in which it meets the given lines.

(b) Show that the lines \( \frac{x-5}{4} = \frac{y-7}{4} = \frac{z+3}{-5} \) and \( \frac{x-8}{7} = \frac{y-4}{1} = \frac{z-5}{3} \) are coplanar, find their common point and the equation of the plane in which they lie.

8. (a) Find the equation of the spheres which pass through the circle \( x^2 + y^2 + z^2 - 4x - y + 3z + 12 = 0 \), \( 2x + 3y - 7z - 10 = 0 \) and touch the plane \( x - 2y + 2z = 1 \).

(b) Find the condition that the plane \( lx + my + nz = p \) may be a tangent plane to the conicoid \( ax^2 + by^2 + cz^2 = 1 \) and find the coordinates of the point of contact to the conicoid.
SECTION - A

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

1. (a) What are the lines of force? How they are related with electric field strength?
   (b) Using Coulomb’s law show that the electric field due to an infinite line of charge at a point is given by \( E = \frac{A}{2\pi \epsilon_0 r} \), where the symbols have their usual meanings. Prove also the same using Gauss’s law.
   (c) Two equal and opposite charges of 5 \( \mu \)C are separated by 16 cm from each other forming an electric dipole. Calculate the electric field intensity at a point 50 cm from the middle point of the dipole on the equatorial line.

2. (a) What do you mean by capacitance? Calculate the capacitance of a parallel-plate capacitor using Gauss’s law.
   (b) Derive the equation \( q = q_0 (1 - e^{-\frac{i}{\tau}}) \) and \( i = i_0 e^{-\frac{i}{\tau}} \) for charging in a RC circuit, where the terms have their usual meanings. How does the charging depend on the value of the time constant?
   (c) What is the capacitance of the earth, viewed as an isolated conducting sphere of radius 6370 km?

3. (a) State and explain Faraday’s law and Lenz’s law for electromagnetic induction.
   (b) Define coefficient of self-induction. Obtain an expression for the magnetic field of a solenoid near the center of the solenoid and hence find the inductance of the solenoid per unit length.
   (c) A coil having 25 turns with radius of 50 mm has resistance 2 ohms. The perpendicular component of the external magnetic field through the coil increase from 0 to 20 T in 5 sec. What is the magnitude and direction of the induced current?

4. (a) What is meant by crystalline solid? Draw the unit cell structure of NaCl crystal.
   Write down Bragg’s law for X-ray diffraction and mention each terms.
   (b) Distinguish between intrinsic and extrinsic semiconductors. Derive an expression for conductivity of an intrinsic semiconductor.
   (c) Briefly explain the various types of point defects in a crystal.
There are FOUR questions in this section. Answer any THREE.

5. (a) What is point lattice? Draw the following unit cells:-(i) SC lattice (ii) BCC lattice and (iii) FCC lattice
(b) Find the relation between the edge of the unit cell and the atomic radius for BCC lattice. What is packing fraction? Calculate the packing fraction for FCC lattice.
(c) What is a single crystal? Sodium (Na) is a BCC crystal. It's density is $9.6 \times 10^2$ kg/m$^3$ and atomic weight 23 amu. Calculate the lattice constant for a sodium crystal.

6. (a) Explain Miller indices. Distinguish between ionic and covalent bonds.
(b) Draw the (110) and (111) planes in a simple cubic crystal. Draw the graphs for the variations of the attractive energy, repulsive energy and total energy versus interatomic distance in a system of two atoms. What is Madelung energy? Evaluate the Madelung constant for a linear ionic crystals.
(c) How many atoms per mm$^2$ surface area in (100) plane for copper which has the fcc structure and a lattice constant $a = 3.61 \times 10^{-10}$m.

7. (a) Explain relativity of simultaneity, length contraction, and time dilation using Lorentz transformation equation.
(b) What are the basic modifications done on the Michelson-Morley interferometer to detect gravitational wave in the Laser Interferometer Gravitational-Wave Observatory?
(c) What is a black body? How does Planck's radiation formula remove the problem of ultraviolet catastrophe in explaining the radiation spectrum of a black body?
(d) An orbiting satellite can become charged by the photoelectric effect when sunlight ejects electrons from the vehicle's outer surface and satellites have to be designed to minimize such charging. If the satellite is coated with platinum, a metal with a particularly large work function of 5.32 eV, what will be the longest wavelength of incident sunlight that can eject an electron?

8. (a) Using the uncertainty principle show that electron cannot stay inside the nucleus.
(b) If the number of nucleons in a copper nucleus is 64 and the number of nucleons in an oxygen nucleus is 16, how much larger is a copper nucleus than an oxygen nucleus?
(c) Explain different types of radioactive decay and nuclear reactions. An old wooden piece has 25.6% of radioactive carbon as compared to ordinary wood. Find its age, if its half-life is 5760 years.
(d) What are the three situations of nuclear Fission reaction and what are the uses of these situations in applied sectors?
SECTION - A

1. (a) A manufacturer has a fixed cost of $160,000 and a variable cost of $160 per unit made and sold. Selling price is $500 per unit.

(i) Find the revenue, cost and profit functions using q for the number of units.
(ii) Compute profit if 150000 units are made and sold.
(iii) Find the break-even quantity.
(iv) Construct the break-even chart. Label the cost and revenue lines, the fixed cost line, and the break-even point.

(b) Complete the following table and sketch the graph explaining the relations among the various short run cost curves.

<table>
<thead>
<tr>
<th>Quantity of output</th>
<th>Total fixed cost</th>
<th>Total variable cost</th>
<th>Total cost</th>
<th>Average fixed cost</th>
<th>Average variable cost</th>
<th>Average total cost</th>
<th>Marginal cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>90</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>90</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>90</td>
<td>45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>90</td>
<td>55</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>90</td>
<td>75</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>90</td>
<td>120</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. (a) From the following revenue and cost functions calculate the profit maximizing level of output and maximum profit.
\[
R = 111Q - 2Q^2 \\
C = \frac{1}{3}Q^3 - 8Q^2 + 122Q + 50
\]

(b) Graphically explain the short run equilibrium of a firm under perfect competition.

3. (a) Explain producer's equilibrium with the help of iso-cost and isoquant curves.

(b) From the following functions calculate the amount of labour and capital that maximize output. What is the maximum amount of output?
\[
Q = 300L^{0.5}K^{0.5} \\
4000 = 30L + 50K
\]

4. (a) What do you understand by localization of industries? What are the causes of localization of industries?

(b) Explain the advantages and disadvantages of localization of industries.
5. (a) How would you construct the market demand and market supply curves? Graphically explain the interactions between these two curves that determine the equilibrium price and quantity of a commodity in the market economy. (13 \frac{1}{3})

(b) The demand and supply functions of Maxell ball point pen are given below:

\[ Q_d = 1570 - 85P_m \]
\[ Q_s = 766 + 32P_m. \]

Find the equilibrium price and quantity of the commodity.

(i) If the Government imposes 18% VAT per unit, what would be the new equilibrium price and quantity?
(ii) Calculate the amount of the VAT that the consumers will actually bear per unit. (10)

6. (a) What do you understand by income elasticity and cross-price elasticity of demand? What is Engel's Law? Describe its implications in economics. (13 \frac{1}{3})

(b) Given the demand function of a commodity X:

\[ Q_{dx} = 1360 - 25P_x + 0.008M + 2.4P_y - 4.5P_z \]

Where, price of X, \( P_x = \) tk. 25, price of Y, \( P_y = \) tk. 45, price of Z, \( P_z = \) tk. 18 and income, \( M = \) tk. 60000. Find the cross-price elasticities and income elasticity of X. State the implications of the results you have obtained. (10)

7. (a) Define indifference curve. Construct an indifference curve from a hypothetical utility schedule for two commodities say, mango and apple. Show the relationship between Marginal Rate of Substitution (MRS) and Marginal Utility (MU). (13 \frac{1}{3})

(b) What do you know about an indifference map? Show the optimum consumption point of a rational consumer given the prices of the commodities and budget line of the consumer. (10)

8. (a) Explain the methods of measuring gross domestic product (GDP) with qualifications. Why should we take account of 'inflation' and 'purchasing power parity (PPP)' when measuring GDP? (13 \frac{1}{3})

(b) What is aggregate demand (AD)? Illustrate the circular flow income model in an open economy. (10)
SECTION A

There are FOUR questions in this section. Answer any THREE.
All symbols have their usual meanings.

1. (a) Assume that the current \( i = I_m \sin(\omega t) \) flows through a given RLC series branch. Show that the voltage across the branch is:

\[
v = I_m Z \sin(\omega t + \theta) = V_m \sin(\omega t + \theta)
\]

where

\[
Z = \sqrt{R^2 + \left(\frac{\omega L}{\omega C} - \frac{1}{\omega C}\right)^2}
\]

and \( \theta = \tan^{-1}\left(\frac{\omega L - \frac{1}{\omega C}}{R}\right) \)  

(b) Find the value of the reactance \( (X) \) in Fig. for Q. 1(b) which will make the overall power factor 0.707 lagging.

2. (a) Define form factor and crest factor.

(b) Determine the phase difference between the voltage signals \( v_1 = -100 \sin(\omega t - 10^\circ) \) and \( v_2 = -10 \cos(\omega t + 40^\circ) \). Also identify the leading voltage signal.

(c) Find the RMS value of the periodic voltage shown in Fig. for Q.2(c).
(b) From the circuit of Figure for question no 5(b), determine \( \nu_0 \) using nodal analysis.

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6. (a) Consider the following circuit of Figure for question no 6(a).

(i) Determine the Thevenin equivalent of the circuit between a and b terminals.
(ii) Find the value of \( R_L \) for maximum power transfer in the circuit. Also determine the maximum power.

(b) Use superposition theorem to determine the value \( \nu_0 \) in the circuit of Figure for question no 6(b).
EEE 165

3. (a) With necessary equations and vector diagram, prove that the total power of a balanced three-phase load can be measured using two wattmeter method.  
(b) A 3-phase Y-connected motor takes 10 kVA at 0.6 power factor lagging from a source of 220 volts. It is in parallel with a balanced delta load having 16Ω resistance and 12Ω capacitive reactance in series in each phase. Find the total volt-amperes, power, line current, and power factor of the combination.  

4. (a) Discuss about different losses occur in a transformer.  
(b) A 50 kVA, 2400/240V transformer has the following test data:  

<table>
<thead>
<tr>
<th>Voltage (V)</th>
<th>Current (A)</th>
<th>Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short circuit test (HV side)</td>
<td>55</td>
<td>20.8</td>
</tr>
<tr>
<td>Open circuit test (LV side)</td>
<td>240</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Calculate the voltage regulation and efficiency when the transformer is connected to a load that takes 156 A at 220 and 0.8 power factor lagging.  
(c) Draw the complete vector diagram of the circuit shown in Fig. for Q. 4(c). Use I₁ as references for the diagram.

**SECTION - B**

There are FOUR questions in this section. Answer any THREE.  
All symbols have their usual meanings.

5. (a) Find the equivalent resistance $R_{ab}$ in the following circuit.
EEE 165

7. (a) Use mesh analysis to determine the current $i_0$ in the circuit of Figure for question no 7(a).

(b) Draw the "Fittings and Fixture Layout Design" in Figure for question no 7(b) and attach this sheet with your answer script.

8. (a) Describe and derive the equivalent circuit of an induction motor.

(b) A 480-V, 50-Hz, 50-hp, three-phase induction motor is drawing 60 A at 0.85 PF lagging. The stator copper losses are 2 kW, and the rotor copper losses are 700 W. The friction and wind age losses are 600 W, the core losses are 1800 W, respectively, and the stray losses are negligible. Find the following quantities:

(i) The air-gap power, $P_{AG}$
(ii) The power converted, $P_{conv}$
(iii) The output power, $P_{out}$
(iv) The efficiency of the motor, $\eta$. 

-------------------------------------------------------------------
Figure for question no. 7(b)
SECTION - A
There are FOUR questions in this section. Answer any THREE.

1. (a) Explain the mechanism of setting a perpendicular line with the help of an optical square where the angle between two internal mirrors is 45°.

(b) Define: (i) Magnetic Bearing (ii) Independent Co-ordinate

There is an obstacle in the form of a pond on the main chain line AB as shown in Figure 1. Two points C and D were taken on the opposite sides of the pond. On the left of CD, a line CE was laid out 100m in length and a second line CF, 80 m long was laid out on the right of CD, such that E, D and F are in the same straight line. ED and DF were measured and found to be 60 m and 56 m respectively. Find out the obstructed length CD.

(c) Mention the characteristics of a closed traverse. Briefly explain the procedure of adjusting closing error.

2. (a) From a common point A, traverses are conducted on either side of a harbor as follows:

<table>
<thead>
<tr>
<th>Traverse</th>
<th>Line</th>
<th>Length(m)</th>
<th>Bearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AB</td>
<td>240</td>
<td>85°26'</td>
</tr>
<tr>
<td></td>
<td>BC</td>
<td>120</td>
<td>125°11'</td>
</tr>
<tr>
<td>2</td>
<td>AD</td>
<td>270</td>
<td>175°50'</td>
</tr>
<tr>
<td></td>
<td>DE</td>
<td>600</td>
<td>85°07'</td>
</tr>
</tbody>
</table>

Calculate (i) distance from C to a point F on DE due south of C and (ii) Distance EF [hint: CF represents South axis of C]

(b) What are the purposes of levelling? Differentiate between self-reading staff and target staff.
(c) In a proposed hydro-electric project, a storage was required to provide a storage of 9.0 million m$^3$ between Lowest Drawdown (L.D.D) and Top WL (T. WL). The area contained within the stated contours of a upstream face of the dam were as follows:

<table>
<thead>
<tr>
<th>Contour(m)</th>
<th>200</th>
<th>195</th>
<th>190</th>
<th>185</th>
<th>180</th>
<th>175</th>
<th>170</th>
<th>165</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area(ha)</td>
<td>60</td>
<td>50</td>
<td>46</td>
<td>34</td>
<td>30</td>
<td>26</td>
<td>14</td>
<td>9</td>
</tr>
</tbody>
</table>

If L.D.D was to be 168 m calculate the T.W.L for 70% full storage capacity.

3. (a) Derive the distance and elevation formula for inclined sights with staff remain vertical, provided that the line of sight has a vertical elevation angle.

(b) The following readings have been taken from a page of an old level book. It is required to reconstruct the page. Fill up the missing quantities and apply the arithmetic check.

<table>
<thead>
<tr>
<th>Point</th>
<th>B.S (m)</th>
<th>I.S (m)</th>
<th>F.S (m)</th>
<th>Rise (m)</th>
<th>Fall (m)</th>
<th>R.L (m)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.125</td>
<td>x</td>
<td>x</td>
<td>1.325</td>
<td>0.055</td>
<td>x</td>
<td>B.M</td>
</tr>
<tr>
<td>2</td>
<td>x</td>
<td>1.325</td>
<td>125.505</td>
<td>T.P</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2.320</td>
<td>x</td>
<td></td>
<td>0.055</td>
<td>125.850</td>
<td>T.P</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>x</td>
<td>2.655</td>
<td></td>
<td>2.165</td>
<td>T.P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>x</td>
<td>2.655</td>
<td></td>
<td>2.165</td>
<td>T.P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1.620</td>
<td>3.205</td>
<td>2.165</td>
<td>2.655</td>
<td>T.P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>3.625</td>
<td>x</td>
<td></td>
<td>123.090</td>
<td>T.B.M</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Where, B.S = Back Sight; F.S=Fore Sight, R.L= Reduced Level; B.M=Bench Mark; T.P= Turning Point and T.B.M= Temporary Bench Mark.

(c) For the following natural features, what would be the typical contour map?

(i) River  (ii) Valley line (iii) overhanging cliff

4. (a) Write down the advantages and disadvantages of using anallatic lens in 'Tacheometric Survey'.

(b) A tacheometer is set up at an intermediate point on a traverse course PQ and the following observations are made on a vertically held staff:

<table>
<thead>
<tr>
<th>Staff station</th>
<th>Vertical angle</th>
<th>Staff intercept (m)</th>
<th>Axial hair readings (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>+8°36'</td>
<td>2.350</td>
<td>2.105</td>
</tr>
<tr>
<td>Q</td>
<td>+6°6'</td>
<td>2.055</td>
<td>1.895</td>
</tr>
</tbody>
</table>

The instrument is fitted with an anallatic lens and the constant is 100. Compute the length of PQ and reduced level of Q, that of P being 321.50m.

(c) How 'Robotic Total Station' facilitates survey operations? Briefly explain the functions of total station.
5. (a) Briefly discuss the principle of Eco-sounding with sketch. Discuss the shoreline surveying and its objectives. 

(5+5=10)

(b) Differentiate the operational principle of Wire gauge and Float gauge for measurement of stage.

(8)

(c) The followings are the data obtained in a stream gauging operation in which current meter with a calibration equation, \( V = 0.32N + 0.032 \) m/s where \( N \) = number of revolutions per seconds. Using the area-velocity method, calculate the mean discharge, mean velocity and the total cross sectional area.

(17)

<table>
<thead>
<tr>
<th>Distance from right bank (m)</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>9</th>
<th>12</th>
<th>15</th>
<th>18</th>
<th>20</th>
<th>22</th>
<th>23</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (m)</td>
<td>0</td>
<td>0.5</td>
<td>1.10</td>
<td>1.95</td>
<td>2.25</td>
<td>1.85</td>
<td>1.75</td>
<td>1.65</td>
<td>1.50</td>
<td>1.25</td>
<td>0.75</td>
<td>0</td>
</tr>
<tr>
<td>No of revolutions</td>
<td>0</td>
<td>80</td>
<td>83</td>
<td>131</td>
<td>139</td>
<td>121</td>
<td>114</td>
<td>109</td>
<td>92</td>
<td>85</td>
<td>70</td>
<td>0</td>
</tr>
<tr>
<td>Time (sec)</td>
<td>0</td>
<td>180</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>150</td>
</tr>
</tbody>
</table>

6. (a) Differentiate between (i) Arc and Chord Definition of degree of a curve (ii) One theodolite and two theodolite method for ranging a circular curve.

(4+6=10)

(b) Two roadways meet at an angle of 110°. It is proposed to insert a circular curve of 6 chains radius with transition curve at the ends. The super elevation is 14 cm, the rate of attainment of super elevation by the vehicle is 2 cm/s and the vehicle speed is 50 km/hr. Calculate the data to set out the combined curve (full of one transition curve and half of the circular curve) by deflection angle method. Chainage at the point of intersection is 10+25 and length of the chain is 30 m. Take the interval, \( x \) as equal to half of a chain length for the transition curve.

(20)

(c) Sketch a circular curve and identify the elements of the curve.

(5)

7. (a) Differentiate between the followings (i) Side and Eccentric Camera Station (ii) Overlap and Side lap of Aerial photographs.

(6)

(b) Discuss the fundamental principle of determining horizontal and vertical position of a point in a terrestrial photogrammetry.

(12)

(c) An area, 100km long in the north-south direction and 50km in the east west direction is to be photographed with a lens having 21 cm focal length for the purpose of compiling a topographic map. The size of photograph is 18cm \( \times \) 18cm. The average scale is to be 1 : 20000 at an average ground surface elevation of 500m above mean sea level. Overlap is to be at least 60% and side lap is to be 20%. The ground speed of the aircraft will be maintained as 300km/hr. Determine (i) Flight height (ii) No. of flights required (iii) Actual ground distance between flight lines (iv) Exposure interval (v) Total number of photographs.

(17)
8. (a) Write short note on: (i) Ground control in Aerial photogrammetry (ii) Crabbing and Drifting in Aerial photogrammetry. (6)

(b) The following perpendicular offsets were taken from a chain line to a hedge. Calculate the area between the survey line, the hedge and the end offsets using Simpson’s rule. (14)

<table>
<thead>
<tr>
<th>Chainage (m)</th>
<th>0</th>
<th>15</th>
<th>30</th>
<th>60</th>
<th>90</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offset (m)</td>
<td>7.6</td>
<td>8.0</td>
<td>10.0</td>
<td>12.0</td>
<td>7.5</td>
<td>8.0</td>
</tr>
</tbody>
</table>

(c) A plot ABCDE as shown in Figure 2 forms the plane of a pit excavated for road work. Calculate the volume of excavation from the following data. (15)

<table>
<thead>
<tr>
<th>Point</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original level (m)</td>
<td>45.5</td>
<td>50.21</td>
<td>52.7</td>
<td>48.7</td>
<td>52.0</td>
</tr>
<tr>
<td>Final level (m)</td>
<td>39.5</td>
<td>38.5</td>
<td>43.2</td>
<td>42.8</td>
<td>43.1</td>
</tr>
</tbody>
</table>

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Figure 2.
SECTION A

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

1. (a) What do you mean by simple harmonic oscillation? Explain why it is difficult to obtain simple harmonic oscillation.
   (b) Assume that two harmonic signals originating from a signal generator superimposed on an electron. The signals can be represented by, \( x = A \sin \omega t \) and \( y = A \sin(\omega t + \theta) \), where the symbols have their usual meanings. What could be the possible traces of the electron if the phase difference \( \theta \) between the two signals varies?
   (c) A block of mass \( M = 5.4 \text{ kg} \), at rest on a horizontal frictionless table, is attached to a rigid support by a spring of spring constant \( k = 6000 \text{ N/m} \). A bullet of mass \( m = 9.5 \text{ g} \) and velocity of magnitude 630 m/s strikes and is embedded in the block (as in figure Q. 1(c)).

Assuming the compression of the spring is negligible until the bullet is embedded, determine
(i) the speed of the block immediately after the collision, and
(ii) the amplitude of the resulting simple harmonic motion.

2. (a) What do you mean by damped harmonic oscillation? Name the different forces acting on a damped vibration and hence derive the differential equation of motion for damped vibration.
   (b) Solve the differential equation of motion for damped vibration and show how the displacement of an object varies during damped vibration.
   (c) A damped harmonic oscillator consists of a block (\( m = 2.00 \text{ kg} \)), a spring (\( k = 10.0 \text{ N/m} \)), and a damping force (\( F_d = bv \)). Initially, it oscillates with amplitude of 25.0 cm; because of the damping, the amplitude falls to three-fourths of this initial value at the completion of four oscillations.
      (i) What is the value of \( b \)?
      (ii) How much energy has been “lost” during these four oscillations?
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3. (a) Define forced oscillation. Distinguish between the stationary and transient state of an object undergoing forced oscillation.
(b) Due to damping, the energy of harmonic oscillation dissipates in every successive cycle and the oscillation dies out. One way to sustain the simple harmonic oscillation is to feed energy to the system in each cycle from an outside source. Derive an expression for the average power output need to be supplied per cycle to an oscillatory system from an outside periodic source in order to maintain the simple harmonic motion.
(c) Consider a damped oscillation with \( m = 0.2 \text{ kg} \), \( b = 4 \text{ N·m}^{-1} \cdot \text{sec} \) and \( k = 100 \text{ N/m} \). Suppose that this oscillator is driven by a periodic force, \( F = F_0 \cos \omega t \) where \( F_0 = 2\text{N} \) and \( \omega = 30 \text{sec}^{-1} \).

   (i) What is the value of amplitude and phase for steady state case?
   (ii) How much energy is dissipated against the resistive force in one cycle?
   (iii) What is the mean power input?

4. (a) What are Newton's rings? Mention few applications of Newton's ring experiment.
(b) In Young's double slit experiment, how can you determine the resultant intensity of the interfered light wave? Mention the conditions for maxima and minima.
(c) The distance between the slit and biprism, and between biprism and eyepiece are 45 cm each. The obtuse angle of biprism is 178° and the refractive index of the material of prism is 1.5. If the fringe separation is \( 15.6 \times 10^{-3} \text{cm} \), calculate the wavelength of light used.

SECTION - B

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

5. (a) Mention the differences between Fresnel and Fraunhofer classes of diffraction.
(b) Discuss the Fraunhofer diffraction of light at a single slit. Mention the conditions for principal maximum, secondary maxima and minima.
(c) A diffraction grating which has 4000 lines per cm is used at normal incidence. Calculate the dispersive power of the grating in the third order spectrum in the wavelength region 5000 Å.

Contd ........... P/3
6. (a) What do you mean by polarization of light? Write short notes on dichroism.  
(b) State Malus’ law and Brewster’s law. Show that \( i_p + r = \frac{\pi}{2} \), where the symbols have their usual meanings.  
(c) Calculate the thickness of a quarter wave-plate for the light of wavelength 5893 Å. The refractive indices for ordinary ray and extraordinary ray are 1.544 and 1.533, respectively.  

7. (a) Draw the circuit diagrams of platinum resistance thermometer and thermo-electric thermometer mentioning the name of all parts of them.  
(b) Explain with diagram how a thermo-electric thermometer to be used for the measurement of temperature? What do you mean by calibration curve of a thermocouple?  
(c) Calculate the value of unknown resistance by a thermocouple having a mean thermoelectric power of 50 µV/°C. The potentiometer wire is 10 m long having a resistance 0.05 ohm per cm and is used in series with a cell of emf 2 volts and a resistance of 2550 ohms. The balance point is obtained with a length of 520 cm of the wire between the thermocouple terminals. The cold junction is at 0°C.  

8. (a) What do you understand by degrees of freedom of a gas? Explain about the total no. of degrees of freedom for linear and non-linear polyatomic gas molecules.  
(b) State and prove the principle of equipartition of energy. Show that the ratio of two specific heats \( \frac{C_p}{C_v} = 1 + \frac{2}{n} \) for a perfect gas whose molecule have n degrees of freedom.  
(c) Find (i) KE of translation per molecule, (ii) total KE of molecule, and (iii) total KE per mole for oxygen at 30°C. Given Boltzmann’s constant \( k = 1.38 \times 10^{-23} \text{ JK}^{-1} \).