SECTION – A

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

1. (a) A 500 N cylinder rests on a smooth inclined plane as shown in the Figure- 1. For a tension in the rope of 250 N, find the inclination of the plane, θ and the plane reaction. (15)

(b) A continuous string ABCDE as shown in the Figure-2 passes over smooth pegs at B and D, 10 m on centers. To the ends of the string are attached the weights \( W_A = 7 \) N and \( W_C = 5 \) N. A 10 N weight is also attached at C and the three bodies are in equilibrium. Determine the distance \( a \) and the angle \( α \). (20)

2. (a) A frame structure is shown in the Figure- 3, find the horizontal and vertical components of the pin load at C and the load on the member HK. (15)

(b) A three hinged arch is shown in the Figure- 4. Determine the components of the pin reactions at A, B and C; and find the loads on the member DB and EB. (20)

3. (a) What is a catenary curve? Derive the equation for the length of a catenary? (10)

(b) Three wedge A, B and C are shown in the Figure- 5, each weighs 500 N. Find the force Q that is needed if counterclockwise rotation of the lever is impending. Assume \( f = \frac{1}{4} \) for all surfaces. (15)

(c) Two bodies are connected by a rope and pulley system which is capable of moving at smooth bearing C as shown in the Figure- 6. For \( W_A = 2000 \) lb, \( f_2 = 1/3 \) and \( f_3 = 0.15 \). Determine the weight of B for impending clockwise motion of the pulley. (10)

4. (a) Two Electric cables AC and BC terminate on a pole and exert forces in a horizontal plane at C as shown in the Figure-7. The tension in the cables AC and BC are 5000 N and 8000 N respectively and \( θ = 30^° \). The guy cable makes an angle of 45° with the pole. Find the value the angle \( α \), tension in the guy cable CD and force in the pole CE. (12)

(b) Three members AB, BC and BD, each 20 m long form a tripod as shown in the Figure-8. The ends of the timbers on the ground form an equilateral triangle ACD, the sides of which are each 20 m long. If the safe compressive load for each timber is 20,000 N, what safe load \( "W" \) may be suspended from the point B? (12)

(c) Derive the equation for belt friction, where symbols have their usual meanings. (11)
SECTION-B
There are FOUR questions in this section. Answer any THREE.

5. (a) A bullet of mass 20 g is fired horizontally with a velocity of 300 m/s, from a gun carried in a carriage; which together with the gun has mass of 100 kg. The resistance to sliding of the carriage over the ice on which it rests is 20 N. Find (a) velocity, with which will recoil, (b) distance, in which it comes to rest, and (c) time taken to do so. (18)

(b) The system of bodies shown in Fig-9 starts from rest. Determine the acceleration of body B and the tension in the string supporting body A. (17)

6. (a) A solid consists of a right circular cylinder and a hemisphere with a cone cutout from the cylinder as shown in Fig-10. Find the centre of gravity of the body. Use \( \frac{2\pi}{3} \times r^3 \) for the hemisphere. (18)

(b) For the shaded area depicted in Fig-11. Determine the x, y of the centroid. (17)

7. (a) Find the moment of inertia of a hollow section shown in Fig-12 about an axis passing through its centre of gravity or parallel X-X axis. (18)

(b) A frustum of a solid right circular cone has an axial hole of 50 cm the diameters as shown in the Fig 13. Find the moment of inertia about geometric axis of this cast iron frustum. (17)

8. (a) In the Fig.14 the weightless cord wraps about a central groove 14 in in diameter and passes over a smooth peg to a 40 lb body B. the central groove is in 24 in disk A which weights \( W_A = 98.8 \) lb and has a radius of gyration with respect to its axis \( k = 9 \) in. If the disk rolled without slipping what is the speed of B after 6 second when the bodies start from rest? What is the tension in the cord? (18)

(b) Show that if a rigid body is in equilibrium the virtual work done by all the forces and moments acting on the body is zero. (17)
BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA
L-1/T-1 Engineering Examinations 2017-2018
Sub: MATH 131 (Differential and Integral Calculus)
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.

1. (a) Discuss the continuity and differentiability of the function
   \[ f(x) = \begin{cases} 
   5x - 4, & 0 < x \leq 1 \\
   4x^2 - 3x, & 1 < x \leq 2 \\
   3x + 4, & x > 2 
   \end{cases} \]
   \text{ at the point } x = 2.

   Also, sketch the graph of the function.

   (b) Evaluate: \( \lim_{x \to 0} (x \ln x) \)

   (c) Find the n-th derivation of \( y = \sin^5 x \cos^4 x \).

2. (a) State Leibnitz’s theorem. If \( y = x \cos(\ln x) \), then show that
   \[ x^2 y_{n+2} + (2n-1)xy_{n+1} + (n^2 - 2n + 2)y_n = 0. \]

   (b) Expand the polynomial \( 2x^3 + 7x^2 + x - 1 \) in power of \( (x-2) \).

   (c) Verify Cauchy’s mean value theorem for the functions \( f(x) = x^2 - 2x + 3 \) and \( g(x) = x^3 - 7x^2 + 26x - 5 \) in the interval \([-1, 1]\).

3. (a) Find the maximum and minimum values of the function \( f(x) = x^3 - 3x^2 + x - 2 \).
   Also, discuss the concavity and find the point of inflection of the function.

   (b) If \( u = f(y - z, z - x, x - y) \), show that \( \frac{\partial u}{\partial x} + \frac{\partial u}{\partial y} = 0 \).

   (c) State Euler’s theorem of homogenous function. If \( u = \tan^{-1}\left[(x^3 + y^3)/(x + y)\right] \),
   show that \( x \frac{\partial u}{\partial x} + y \frac{\partial u}{\partial y} = \sin 2u \).

4. (a) Find the condition that the curves \( ax^2 + by^2 = 1 \) and \( a_1x^2 + b_1y^2 = 1 \) should cut orthogonally.

   (b) Find the pedal equation of the parabola \( y^2 = 4ax \) with respect to its focus.

   (c) Show that the radius of curvature at any point on the cardioid \( r = a(1 - \cos \theta) \) is \( \frac{2}{3} \sqrt{(2ar)} \).
5. Carry out the following: 

(a) \[ \int \frac{dx}{x^3(2+3x)^3} \]

(b) \[ \int \frac{dx}{(x-1)\sqrt{3x-x^2-1}} \]

(c) \[ \int \sec^5 x \, dx \]

6. (a) Find a reduction formula for \( I_n = \int x\cos^n x \, dx \), and hence obtain \( \int x\cos^3 x \, dx \). 

(b) Evaluate \( \int_0^1 \cot^{-1}(1-x+x^2) \, dx \).

(c) Find the value of \( \int_0^{\frac{16}{3}} \frac{\sqrt{x}}{1+\sqrt{x}} \, dx \).

7. (a) Prove that \( \int_0^{\frac{\pi}{2}} \log \sin x \, dx = -\frac{\pi}{2} \log 2 \).

(b) Evaluate: 

(i) \( \beta(p+1,q) + \beta(p,q+1) \)

(ii) \( \int \frac{dx}{\sqrt{1-x^n}} \).

(c) Determine the area inside the circle \( r = \sin \theta \) and outside the cardioid \( r = 1-\cos \theta \).

8. (a) Find the area enclosed by the curve \( a^2y^2 = a^2x^2 - x^4 \).

(b) Find the volume of the solids generated by an arch of the cycloid \( x = a(\theta - \sin \theta), \ y = a(1-\cos \theta) \) about OX.

(c) Evaluate \( \iiint_{0}^{a} x^2y^2z \, dz \, dy \, dx \).
SECTION – A

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

1. (a) What is meant by ‘self-ionization of water’? Justify that water acts both as Brønsted acid and base. (5)
   (b) Discuss the structure and hydrogen bonding of water. Explain with examples the chemical value of water as solvent. (8+7=15)
   (c) What is “heavy water”? How its physical properties differ from normal water? Describe (i) The electrolysis method for the preparation of heavy water and (ii) exchange reactions of heavy water. (7+8=15)

2. (a) Define the terms: electrode and salt-bridge. (5)
   What kind of electrolyte should be used in a salt-bridge?
   (b) Discuss the spontaneity of the electro-chemical reaction in terms of its standard emf ($E^0_{\text{cell}}$).
   Deduce the relationship between $E^0_{\text{cell}}$ and K (equilibrium constant). (8+7=15)
   (c) What is electrolysis? Describe the electrolysis of (i) molten NaCl and (ii) H$_2$O.
   Suppose the electrolysis of molten magnesium chloride is carried out with an applied voltage of 6V and a current of $8 \times 10^4$ A. How much electrical energy (in kwh) is consumed in exactly 1h? (10+5=15)

3. (a) Differentiate between the terms “sol” and “gel”. How a sol differs from a true solution optically? (5)
   (b) Explain the effect of pressure on the solubility of a gas in liquid.
   Using Henry’s law, estimate solubility of O$_2$ in H$_2$O at 25°C and a partial pressure of 190 torr. ($K_{\text{sol}} = 3.30 \times 10^7$ torr). (10+5=15)
   (c) What is peptization? How Fe(OH)$_3$ sol can be prepared by peptization method?
   Discuss the “Brownian movement” and “Electrophoresis” of sol particles. (7+8=15)

4. (a) State mathematically the term “molal elevation constant ($K_b$)”. What is the physical significance of $K_b$? (5)

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(b) Establish a relationship between $K_b$, $\Delta T$ and $c_m$ (where $K_b$ is the molal elevations constant, $\Delta T$ is the boiling point elevation and $c_m$ is the molality of the solution) and thus show how molar mass of a solute can be evaluated. When 3.72 g of dichloroethane is dissolved in 25.0 g of CCl$_4$, the boiling point is raised from 76.5°C to 84.1°C. The value of $K_b$ for CCl$_4$ is 5.03°C kg mol$^{-1}$. Calculate the molar mass of dichloroethane. \(10+5=15\)

(c) Define the water quality parameters – DO, BOD, and COD. How COD can be determined chemically?
Describe different processes for the sterilization of waste water by Cl$_2$. \(7+8=15\)

SECTION – B

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

5. (a) Give an account of Bohr’s theory of atomic structure and show how it explains the occurrence of spectral lines in the atomic spectra of hydrogen. \(12\)

(b) The uncertainty in the position and velocity of a particle are $10^{-10}$m and \(5.27 \times 10^{-24}$ms$^{-1}$ respectively. Calculate the mass of the particle. \(5\)

(c) State Pauli’s exclusion principle and show that the maximum number of electrons in a given shell is \(2n^2\) where $n$ is the principal quantum number of the shell. \(9\)

(d) Compare the properties of ionic and covalent compounds. \(9\)

6. (a) Write a note on Hydrogen bonding. \(6\)

(b) Use the MO theory to predict the bond order and the number of unpaired electrons in O$_2^+$ and NO. \(12\)

(c) Explain the shape of SO$_4^{2-}$, H$_2$S and PCl$_5$ with the help of hybridization. \(9\)

(d) Account for the following with reasons:
   (i) Melting point of MgCl$_2$ is much higher than that of AlCl$_3$.
   (ii) KI is soluble in alcohol but KCl is not. \(8\)

7. (a) Why is HF a weak acid compared with HI in water? \(4\)

(b) Explain the three-centre two-electron bonding of Beryllium hydride. \(7\)

(c) Give equation to show the reactions between Ca and: (i) H$_2$O, (ii) H$_2$, (iii) C, (iv) N$_2$, (v) O$_2$ (vi) Cl$_2$ (vi) NH$_3$. \(9\)
(d) Why are the Group 1 metals soft and low density? (7)
(e) Define hard acid, base and soft acid, base with proper example. (8)

8. (a) Discuss the biological role of heavy metals. (8)
(b) A line at 434 nm in Balmer series of spectrum corresponds to a transition of an electron from the \( n^{th} \) to 2\(^{nd} \) Bohr orbit. What is the value of \( n \)? (7)
(c) Derive Schrödinger wave equation for the wave mechanical model of an atom and discuss its application to hydrogen atom. (12)
(d) Write down the differences between bonding and antibonding molecular orbitals. (8)
There are FOUR questions in this section. Answer Question No. 1 and any TWO from the rest. Symbols indicate their usual meaning.

1. Read the passage carefully and answer the questions that follow:

   People think of poverty as a great evil and it seems to be an accepted belief that if people had plenty of money they would be happy and useful and get more out of life. As a rule, there is more genuine satisfaction in life and more obtained from life in a humble cottage of the poor men than in the palaces of the rich. I always pity the sons and daughters of rich men who are attended by servants and have governesses at a later stage; at the same time, I am glad to think they do not know what they have missed. It is because I know how sweet and happy and pure the home of honest poverty is, how free from perplexing cares and from social envies and jealousies — how loving and united members are in the common interest of supporting the family. It is for these reasons that from the ranks of the poor so many strong eminent self-reliant men have always sprung and must always spring. If you read the best of the immortals, who were born not to die, you will find that most of them were born poor.

   Questions:
   (a) What is the accepted belief about poverty? Do you agree with it? Why/why not?
   (b) Why does the author feel pity for the sons and daughters of rich men?
   (c) How is the home of the honest poverty according to the author?
   (d) How does the author congratulate poor man’s house?
   (e) Write down the meaning of the following words as used in the passage:
   Eminent, perplexing, self-reliant, immortal, humble, spring.

2. (a) Write a letter to a computer supplier shop complaining about the defects of the computers recently purchased from them and asking for an immediate replacement or adjustment of those.

   (b) Transcribe any five of the following words:
   Power, charm, drama, tasty, elephant, captain, police.

3. (a) Write a dialogue between two students of your department on the road safety with a reference to the serious road accident caused by the reckless driving of bus drivers leading to casualties of college students few days back.

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(b) Write a short essay on any one of the following topics:
   (i) Water Logging in Dhaka City: Possible Ways Out
   (ii) Women Empowerment in Bangladesh
   (iii) Your Favourite Teacher

4. (a) Transform any five of the following sentences as directed:
   (i) I know that he is a poet (Simple).
   (ii) Despite having all the qualifications, Adnan could not manage a job (Compound).
   (iii) You can talk to your heart’s content (Complex).
   (iv) We sow so that we may reap (Compound).
   (v) Only a millionaire can afford such extravagance (Negative).
   (vi) We should take a balanced diet and we can be healthy (Complex).

(b) Write short notes on any two of the following:
   (i) Phonetics and IPA symbols
   (ii) Recommendatory Report
   (iii) Tips for performing a dialogue
   (iv) Qualities of a Good Precis

SECTION - B

There are FOUR questions in this section. Answer Question No. 5 and any TWO from the rest. Symbols indicate their usual meaning.

5. (a) Explain with reference to the context any one of the following:
   (i) “You have lost reason and taken wrong path. You have taken lies for truth and hideousness for beauty.”
   (ii) “How singular is life, and how full of changes! How small a thing will ruin or save one!”

(b) Answer any one of the following:
   (i) Draw a character sketch of Laura Sheridan according to the story of “The Garden Party”.
   (ii) Do you think that Mrs. Matilda Loisel suffered more than she deserved? Give your opinion according to the story of ‘The Diamond Necklace’.

(c) Answer any three of the following questions:
   (i) What was the topic of discussion among the guests in the party hosted by the banker?
   (ii) Mention the terms and conditions of the bet made between the banker and the lawyer.
   (iii) What kind of a man was Mr. Loisel?
   (iv) What impression do you get about Mrs. Sheridan?
6. Recast and correct any ten of the following sentences:

   (i) They made less mistakes with the new calculating machine.
   (ii) A trio of boys were scheduled to sing.
   (iii) The militia is discussing the battle among itself.
   (iv) Both of the mouse is underfed.
   (v) Its a long way home.
   (vi) Who do you want to help you?
   (vii) That was me whom you saw yesterday.
   (viii) Abraham Lincoln was one of the great man in American history.
   (ix) The highways were slippery due to the ice.
   (x) Henry does not eat except it is meal time.
   (xi) Chicago is larger than any city in Illinois.
   (xii) He is as tall as, if not taller, than the teacher.

7. (a) Give the meanings of any ten of the following words:
   Acrid, blandishment, cataclysm, eradicate, incidental, malign, pauper, retort, scornful, vestige, yelp, zealot.
   (b) Make sentences with any ten of the following words:
   Aspire, bicker, chore, dungeon, flounder, holocaust, intrepid, molest, protrude, roam, stunt, thrifty.

8. Write a précis of the following passage with a suitable title:

   Men are not made in the same mould, like a lot of bricks. It would have ill suited the wants of the world. Consequently, even in the same country, men differ in disposition, and inclination, and manners, and opinion, more probably than they do in face or form. And between the people of different countries the contrast is even more striking. We have, then, also, different sentiments, different sympathies, different hopes, different ways altogether. It will always be so. So long as there are different minds, there will be different views on all matters that admit of opinion. So long as there are different latitude and longitude, as well as differing circumstances there will be different interests, different attachment and different habits. It behoves us, therefore, to cultivate generous spirit of forbearance towards those, of whatever race, who may think differently and act differently from ourselves. Even though we may be convinced that they are wrong, if we know them to be sincere, we shall still bear with them and give them credit for their sincerity. This is the value of toleration or bearing with others when we may differ from them, or may not like their ways. Tolerateshould be shown in all differences of opinion on even the highest matters of life and death; and here it is of more value than anywhere else. When we agree with one about a point of science, or philosophy or faith, we can at least differ from him, and there is an end. We must always remember that we are likely to make mistakes and weaknesses, and that we ourselves need the same forbearance and sympathy. We are, besides, all the same human brotherhood, and should “like brothers agree”.

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