QUESTIONS PAPERS

END TERM THEOTY EXAMINATION

NOVEMBER-DECEMBER-2019

B. DESIGN

(1st & 3rd SEMESTER)

MSC.- PHYSICS/ MATHEMATICS/ CHEMISTRY

(1ST SEMESTER)

QUESTION PAPERS FOR M.SC. END TERM THEORY EXAMINATION
NOVEMBER-DECEMBER :2019
SEMESTER: I

Total No. of Pages: 02

M.Sc. [BIOTECHNOLOGY]
END SEMESTER EXAMINATION

Roll No. ... .
First Semester
(Nov-2019)

MSBT-101 BIOCHEMISTRY

Time: 3.00 Hours

Max Marks: 75

Note:	Answer all questions. Assume suitable missing data, if any.

1. Give *brief* explanation of *all* of the following [2x9]

(i) High level of triglycerides is associated with heart attack. Clofibrate, a drug that increases the activity of peroxisomes is sometime used to treat this disease. What is the biochemical explanation?

(ii) Although O_2 does not participate directly in the citric acid cycle, the cycle operates only in presence of O_2. Why?

(iii) Why is it so that, most unsaturated fatty acid found in phospholipid are in *cis* rather than *trans* conformation?

(iv) The composition (in molar fraction unit) of one strand of DNA helix is [A] = 0.30 and [G] = 0.24, what can you say about [T] and [C]?

(v) Contrary to legend, camels don't store water in their hump, which actually consist of large fat deposits. How can these fat droplets serve as source of water? Write down the reaction.

(vi) What will be the fate of glycolysis in two conditions? One: if citrate is high and another: if AMP is high

(vii) Patient in shock will often suffer from lactate acidosis due to deficiency of O_2, Why does it happen? One treatment for shock is to administer dichloroacetate drug, which inhibits the kinase associated with pyruvate dehydrogenase complex. What is the biochemical explanation?

(viii) Vitamin C deficiency leads to scurvy disease in which elasticity of the skin is reduced very much, why?

(ix) On the basis of absorbance at 260 and 280 nm, how can you differentiate between DNA and RNA?

2. Attempt any *five* of following [5x5]

a) Explain Ramachandran plot and its significance.
b) Write about regulation of TCA cycle.
c) Describe the pathway which is mainly responsible for production of NADPH.
d) Describe Glycogen catabolism also mention any 2 diseases associated with Glycogen metabolism.
e) Explain effect of GC content on Tm (melting temperature) of DNA and explain the phenomenon of hypochromacity and hyperchromacity.
f) Write down different factors stabilizing DNA double helix. Also discuss tautomerism in DNA base.
g) Define steady state kinetics of enzymes?
h) Define role of binding energy in enzyme catalysis.

3. Attempt any *four* of following [8x4]

I. Describe the process of oxidation of fatty acids. Calculate the total ATP yield out of oxidation of 18 carbon fatty acid. Also discuss the role of insulin in regulation of beta oxidation.
II. Describe different ways of identification and analysis of fats and oils.
III. Describe different secondary and super-secondary structure of proteins with examples, also write down various forces that stabilizes protein structure.
IV. Describe different types of enzyme inhibitions and their effects.
V. Define Enzyme naming and classification, which are different classes of enzymes? How do enzymes achieve transition state stabilization?
VI. Write about different chemical reactions of triacylglycerols, also define Ecosanoids.

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Total No pages: 02 | Roll No................

5TH SEMESTER | M. Sc (Biotechnology)

END SEMESTER EXAMINATION | NOVEMBER 2019

MSBT103: Cell and Developmental Biology

Time: 3 hrs | *Maximum Marks: 100*

Note: Answer should be brief and to the point

1. What do you understand about cell cytoskeleton and why it is important? Mention different types of protein filaments which forms the cytoskeletons in cells. 2+ 3=5

2. Write in very brief the structure, organization and functions of any two of the following 7.5X2=15
   - i) Actin filaments
   - ii) Myosin & cell movement
   - iii) Any one of cytoskeleton proteins and cell movement

3. What do you understand by cell signaling/signal transduction? Mention/list the names of different types of signaling molecules and their receptors. 2+4+4=10

4. Write in brief the structure and function of any one of the following 10
   - i. G Protein-Coupled Receptors
   - ii. Receptor tyrosine kinases
   - iii. The cAMP Pathway

iv. MAP Kinase Pathways

v. Role of cytoskeleton proteins in cell signaling with example

5. What do you understand by cell cycle? List the different phases of cell cycle. 1+4=5

6. Write in very brief any two of the following (giving one example) 7.5X2=15

i. Cell Cycle Checkpoints

ii. Regulation of the Cell Cycle by Cell Growth and Extracellular Signals

iii. Protein Kinases in Cell Cycle Regulation

I. Role of Cyclins and Cyclin-Dependent Kinases in cell cycle

7. What do you understand by programed cell death/apoptosis? Write in brief the events and proteins (executioners, regulators and signaling proteins) involved in program cell death. 2+8=10

8. What do you understand by stem cells? Write the different types of stems cells and their applications in medical science. 2+8=10

9. How do you differentiate between cancer cell and Normal cell? Write in very brief various causes and developmental stages of cancer 2+3=5

10. Write in very brief any two of the following **7.5 X2=15**

i) List of oncogenes and tumor suppressor genes and their role (as a whole) in cancer development?

ii) Different types of Tumor Viruses

iii) Molecular approaches for Cancer diagnosis and treatment

(iii) 31 tRNAs are required to read 61 sense codons
(iv) $tRNA^{fmet}$ is used only in initiation phase but not in elongation phase
(v) Degeneracy of codons minimizes the effects of mutation

Q.5 [A] Fill in the blanks [5]

(a) For a diploid cell, gain-of-function mutation(s) in...copy(ies) of a POG brings about excessive growth
(b) Mutation of ....gene is an important step in the progression of many cancer cells toward the fully malignant state
(c) ....reported genetic elements that can move about the maize genome
(d) ....is an example of SINEs in human
(e) Tc1/Mariner is an example of ....transposon
(f) Two enzymes encoded in LTR retrotransposons are reverse transcriptase and..........
(g) Replicative transposition requires two activities, transposase and ....
(h) Tn3 moves by .... transposition mechanism
(i) .... sequences are preferred cleavage sites for insertion of poly A retrotransposon
(j) An example of active LINE in human is.........
(k) Loss-of-function mutations in p53 related to cancer occurs in its.... domain
(l) A POG is activated to oncogenes, when a regulatory sequence translocated from distant site alters the expression of downstream gene leading to .... synthesis of encoded protein

[B] Attempt any TWO of the following [6]

(a) Explain with respect to pRb: (i) Acts as brake in mammalian G1 phase; (ii) Action depends on its state of phosphorylation; (iii) Positive feedback loop sharpens the G1/S transition
(b) Enumerate various applications of transposon mutagenesis. Explain a typical two-component system for transposon mutagenesis in plants
(c) Describe the mechanism of conservative transposition. Explain in detail different mechanisms for cleavage of non-transferred strands

[C] Attempt any TWO of the following [4]

(a) Give a descriptive account of action of p53 during DNA damage in any two of the following: (i) Cell cycle arrest; (ii) Apoptosis; (iii) Senescence
(b) Write in brief about any two of the following: (i) Philadelphia chromosome; (ii) Insertion elements; (iii) Transposase; (iv) Cointegrate; (v) MDM2
(c) Differentiate between any two of the following: (i) Viral-like and Non-viral like retrotransposons; (ii) Autonomous and Non-autonomous transposons; (iii) LINEs and SINEs; (iv) Complex and Composite transposons

END

Total No. of Pages: 4 Roll No..........

FIRST SEMESTER M.Sc.IBT)

END SEMESTER EXAMINATION Nov-Dec-2019

MSBT105 Molecular Biology

Time: 3:00 Hours *Max. Marks: 75*

Note: Answer *ALL* questions. Assume suitable missing data, if any

Q.1 [A] Assign reasons to any five of the following in 50-100 words [5]

(a) Synthesis of leading and lagging strands is coordinated
(b) β-clamp increases the processivity of DNA Pol III
(c) Only one replication fork trap functions at a time in prokaryotes
(d) Primer length is limited to 11±1 nts during prokaryotic replication
(e) Production of repair proteins is induced during DNA damage
(f) Presence of telomeres prevent loss of genes during replication
(g) HU proteins cause bending of DNA

[B] Briefly describe functions of any six of the following: (a) Matrix attachment regions; (b) Propellor twist; (c) Ku protein; (d) DNA glycosylase; (e) PARP-1; (f) UvrC; (g) *chi* site; (h) RecA; (i) Ada enzyme [6]

[C] Answer the following [4]

(a) Write short notes on any one of the following: (i) Nucleosome phasing; (ii) σ replication; (iii) Structure of metaphase chromosome; (iv) Cot curve and its significance; (v) Cre-*lox* mediated site-specific recombination
(b) Differentiate between any two of the following: (i) Heterochromatin and Euchromatin; (ii) Highly and Moderately repetitive DNAs; (iii) 10 nm and 30 nm fibers; (iv) Renaturation by Fast and Slow cooling

Q.2 [A] Fill any ten of the following blanks [5]

(a) Predominant tautomeric form of guanine in DNA is ....form
(b) If the ends of DNA are not free to rotate,...........superhelicity accumulates ahead of the DnaB generated fork
(c) An example of DNA polymerase possessing 5'→3' exonuclease activity is...
(d) In metazoans, ...binds to Cdt1 and inhibits it from loading MCM2-7
(e) ....represents number of times a somatic cell can divide before ageing
(f) DNA glycosylase removes the flipped out damaged base, leaving ....
(g) ....repair mechanism functions only when there is a second duplex with a normal copy of damaged sequence
(h) ....received Nobel Prize in Chemistry in 2015 shared with T. Lindahl and P. Modrich for mechanistic studies of DNA repair
(i) High processivity of DNA Pol δ and ε is due to ....
(j) Upon binding of tetramer of SSB_{35}, DNA appears as...........string
(k) Naturally occurring DNA is ......supercoiled

P.T.O.

(l) ....in DNA photolyase absorbs photons from blue light

[B] With the help of diagrammatic representation, explain mismatch repair of DNA damage in prokaryotes in detail. Clearly explain the roles of all enzymes/ proteins involved in the process. How is daughter strand distinguished from parent strand in the process? [6]

[C] Answer any two of the following [4]

(a) Write a descriptive account of the resolution of Holliday junction

(b) Differentiate between any two of the following: (i) Short and Long patch BER processes; (ii) Monofunctional and Bifunctional DNA glycosylases; (iii) RecB and RecD; (iv) A-DNA and Z-DNA

(c) Explain any two of the following

(i) Three roles of metal ion Mg^{2+}B in the catalytic action of DNA Pol III

(ii) Significance of tilting of finger domain towards palm domain during catalysis by DNA Pol III

(iii) Process of loading of β-clamp on DNA by γ-clamp loader

Q.3 [A] Fill any ten of the following blanks [5]

(a) The sequence of Pribnow box is ....

(b) Repetitive amino acid sequence in RNA Pol II CTD tail is ....

(c) Corepressor in the regulation of *trp* operon is...........

(d) Lac repressor upon binding the inducer ....allows transcription of *lacZYA*

(e) Trp repressor has ......motif that binds operator

(f) Component of $TF_{II}D$ involved in the initiation of eukaryotic transcription is..

(g) .... alter nucleosome organization by locally disrupting or altering the association of histones with DNA

(h) Presence of glucose in the medium along with lactose switches off the *lac* operon by regulating the cellular concentration of ....

(i) First enzyme involved in 5' capping of eukaryotic pre-mRNA is ....

(j) Mature 5' terminus of tRNA is created due to cleavage catalyzed by.........

(k) .... converts adenine to inosine in tRNA of all eukaryotes

(l) G can post-transcriptionally be substituted by its analog.......in tRNA

[B] Answer any one of the following [6]

(a) Discuss the roles of any two of the following clearly indicating the post-transcriptional event in which each is involved (i) Guide RNA; (ii) Cytidine deaminase; (iii) H/ACA snoRNA; (iv) CPSF

(b) What is meant by GU-AG introns? Describe two transesterification reactions for their splicing. Clearly describe the roles of snRNPs and DEAD box helicases in the process

[C] Answer any two of the following [4]

(a) Explain any two of the following

(i) Lac repressor binds with high affinity to operator

P.T.O.

(ii) Distantly located flap of RNA Pol facilitates the release of RNA from the active site of enzyme

(iii) Acetylation of histones enhances transcription

(iv) Prokaryotic mRNA has lesser half-life as compared to eukaryotic mRNA

(b) Explain the role of *trp* L sequence in the regulation of *trp* operon

(c) Write in brief about any two of the following: (i) Abortive initiations of prokaryotic transcription; (ii) General transcription factors; (iii) Wobble hypothesis; (iv) Interactions of σ subunit with prokaryotic promoter

Q.4 [A] Fill any ten of the following blanks [5]

(a) Ciechanover, Hershko, Rose received 2004 Nobel Prize in Chemistry for describing ......

(b) ......signifies the rotation of tRNA into the PTC for peptide bond formation

(c) In mitochondria, UGA codes for............

(d) ....amino acid is coded by single codon

(e) Wobbling represents relaxation in normal bp rules at the........base of codon

(f) All synonymous codons ending with Py are recognized by ......in anticodon

(g) ....acts as scaffolding protein that links eIF4E to PABP bound to mRNA

(h) An example of post-translational carboxylation of amino acid is in.........

(i) eIF4E has two ....residues that intercalate m^7G of cap

(j) Proteasomal degradation process yields peptides of about.......amino acids

(k) Long peptides containing a series of mature proteins linked together are......

(l) ....catalyzes the interconversion of X-Pro peptide bonds between their *cis* and *trans* conformations

[B] Attempt any TWO of the following [6]

(a) What are inteins? Also write a note on consensus sequences and nucleophilic reactions involved in intein splicing

(b) Briefly describe any two of the following: (i) *cI* and *cro* genes; (ii) Isoacceptor tRNA; (iii) Hybrid states in translation; (iv) Kozak sequence; (v) Ubiquitination; (vi) PDI

(c) Answer any two of the following

(i) How are stop codons recognized? Also explain the mechanism of cleavage of acyl linkage for the release of polypeptide chain

(ii) How does aminoacyl tRNA synthetase catalyze charging of tRNA?

(iii) Enumerate various functions of post-translational modifications

[C] Answer the following [4]

(a) Give an account of the *cis* and *trans* rings of prokaryotic chaperonins and their role in substrate protein folding

(b) Explain any two of the following

(i) Formylation of initiator Met increases the efficiency of translation

(ii) SD sequence helps in initiation of translation from 5' end of mRNA

P.T.O.

Total No pages: 03 | **Roll No................**

1ST SEMESTER | M.Sc. Biotechnology

END TERM EXAMINATION | **NOV-DEC 2019**

MSBT 107: Analytical Techniques

Time: 3 hrs | ***Maximum Marks: 75***

Note: Answer all of the questions.

1. Write short note on any **five.** **5X4**

a. Immobilization of enzyme
b. NMR
c. Mass spectrometry
d. Post translational modification
e. Thin layer chromatography
f. Geiger-Müller counter

2. What is chromatography. Explain stationary and mobile phage in chromatography with some examples? Give the basic principle of HPLC. Explain the separation mechanism with diagram of three proteins of size10 kd, 25kd and 50 kd with gel filtration chromatography. **10**

or

What is an enzyme? Give the classification according to International convention. What are the silent features enzyme during a catalytic reaction and what are the factors which effect the enzyme activity? Explain Enzyme kinetics with Michalis -Menten model.

10

P.T.O

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3. Differentiate between any **four**: 4X2.5

a. Agarose gel electrophoresis and PAGE
b. Radioactive and Stable isotopes
c. Prokaryotic and eukaryotic RNA polymerase
d. Hanging drop and sitting drop crystallization
e. Ion exchange and affinity chromatography

4. Answer any **Four**: 4X5

a. What is radioactivity? What are the three classification of methods, give principle for its detection? Explain any one technique.

b. What is the centrifugation? Give the basic principle and mathematic equation for it. Explain ultracentrifugation techniques and its applications.

c. What is beer-lambert's law explain with the derivation. What are the major applications?
Guanosine has a maximum absorbance of 275 nm. $\epsilon 275$ is 8400$M^{-1}cm^{-1}$ and the path length is 1 cm. using a spectrophotometer, Absorbance at 275 is 0.70. What is the concentration of guanosine?

d. What are detergents? Explain classification with examples. What is the mechanism and applications for detergent for membrane protein purification?

e. What is dosimetry in radiations exposure? What are external and internal dosimetry? Explain different steps for dose is calculations? What are active and passive dosimeter?

P.T.O

5. Answer the following **(any three)**: 3X5

a. What is peptide synthesis? Explain with basic principle.
b. What are TATA binding proteins (TBP) and TAF, explain?
c. Explain autoradiography with it's applications.
d. What is radioimmunoassay and its applications.
e. Explain MALDI TOF with application?

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Total no. of pages: 2
SECOND SEMESTER

Roll no.__________
M. Sc. Biotechnology

END SEMESTER EXAMINATION

December-2019

MSBT-109 BIOSTATISTICS AND COMPUTER APPLICATIONS

Time: 3:00 Hours *Max. marks: 100*

Part A

1. Write short notes on (any 4): **10 marks**
   a) Force field
   b) Protein data bank (PDB)
   c) NCBI
   d) ECDC
   e) Principal Component Analysis (PCA)

2. The annual salaries of employees in a large company are approximately normally distributed with a mean of \$50,000 and a standard deviation of \$20,000. **10 marks**
   a) What percent of people earn less than \$40,000?
   b) What percent of people earn between \$45,000 and \$65,000?
   c) What percent of people earn more than \$70,000?

3. A certain chemical pollutant in a river has been constant for several years with mean 34 units and standard deviation 8 units. A group of company representatives whose company discharges liquids into the river is now claiming that they have lowered the average with improved filtration devices. A group of environmentalists will test to see if this is true at 1% level of significance. Assume that their sample of size 50 gives a mean of 32.5 units. Perform a hypothesis test at 1% level of significance and state your decision. **10 marks**

4. Find the best local alignment between the following 2 sequences, using, score for match = 10, score for mismatch = -5, gap penalty = -7: **15 marks**
   AGCGTAG
   CTCGTC

Part -B

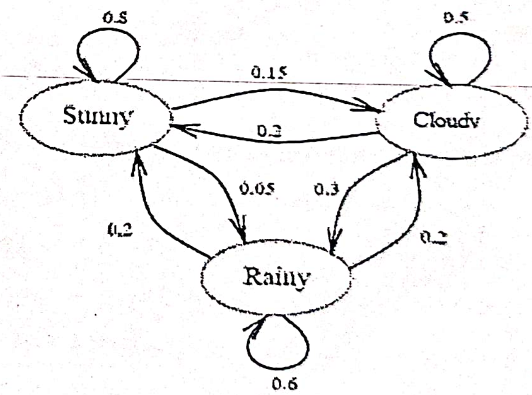
5. Calculate the simple matching coefficient and Jaccard coefficient in the following dataset: **5 marks**
   A: 1 1 0 0 1
   B: 0 0 0 1 1

OR

The sequences below are in PROSITE language. Convert them into readable format.
   a) A-X-[ST](2)-X-V
   b) [MF]-X-[QA]-X-{E}-X(2)-[VY]

6. State the principle behind Nuclear Magnetic resonance. Write its 2 applications. **5 marks**
   OR
   What is the principle behind X-ray crystallography? State Bragg's law.

7. At any given day, the weather can be described as being Sunny, Cloudy or Rainy. Using the following hidden markov state diagram, find the following: **10 marks**
   a) Given that today is sunny, what's the probability that tomorrow will be sunny and next day rainy?
   b) If today is cloudy, find the probability that tomorrow will be rainy.



OR

Explain the procedure of DNA microarray with suitable example.

8. The runs scored in a cricket match by 11 players is as follows: **5 marks**

7, 16, 121, 51, 101, 81, 1, 16, 9, 11, 16

Find the mean, mode, median of this data.

OR

There are 5 green 7 red balls. Two balls are selected one by one without replacement. Find the probability that first is green and second is red.

9. Define three main computational methods of protein modeling. **5 marks**

OR

Predict the output of following C program:

```
#include <stdio.h>

int main () {
  int a = 3;
  float b = 4.5;
  double c = 5.25;
  float sum;

printf("The sum of a, b, and c is: ");
scanf (" %f" , sum);
}
```

10. Suppose that we have a rolling die. We assume that the die is unbiased (upon rolling the die, each outcome is equally likely). An experiment is conducted in which the die is rolled 240 times. The outcomes are in the table below. At a significance level of $\alpha = 0.05$, use chi square test to check if there is enough evidence to support the hypothesis that the die is unbiased? **10 marks**

Outcome	1	2	3	4	5	6
Frequency	34	44	30	46	51	35

OR

a) Divide the given dataset into 2 clusters using k-means clustering algorithm:
X = {2, 4, 10, 12, 3, 20, 30, 11, 25}

b) Write a note on hierarchical clustering.

11. Using the position specific scoring matrix for following sequences, **15 marks**

T C A C A C G T G G G A
G G C C A C G T G C A G
T G A C A C G T G G G T
C A G C A C G T G G G G
T T C C A C G T G C G A
A C G C A C G T T G G T
C A G C A C G T T T T C
T A C C A C G T T T T C

Find the probability of sequence: TGACACGTGGGG

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FIRST SEMESTER Roll No:...............................

END SEMESTER EXAMINATION **M.Sc.**

(NOV. 2019)

MSMA-101, Abstract Algebra

Time: 3 Hrs.

Max. Marks: 100

Note: *Attempt all questions by choosing any two parts from each question. All questions carry equal marks. Assume suitable missing data if any.*

1. (a) *Define a subgroup with an example. Let H and K be finite subgroups of a group G such that HK is also a subgroup of G. Then show that $o(HK) = \frac{o(H)o(K)}{o(H \cap K)}$.*

   (b) *Show that the set of all prime residue classes modulo n forms a group with respect to the binary of multiplication modulo n. Also state and prove Euler's and Fermat's theorems.*

   (c) *Define isomorphism with an example and show that any group of order 4 is abelian.*

2. (a) *Define automorphism with an example. Find all the automorphisms of S_3.*

   (b) *Define a quotient group with and example. Let $H, K < G$ where $H \lhd G$, then show that $H \cap K \lhd K$ and $\frac{HK}{H} \cong \frac{K}{H \cap K}$.*

   (c) *Define an alternating group with an example. Show that A_n is normal subgroup of S_n and $o(A_n) = n!/2$.*

3. (a) *Define Sylow's p-subgroup. State and prove Cauchy's Theorem?*

   (b) *State and prove second Sylow's Theorem?*

   (c) *Show that the alternating group A_n is simple for $n \geq 5$.*

4. (a) *In a ring R with unity,* $(xy)^2 = x^2y^2$ *for all* $x,\ y \in R$ *then show that R is commutative.*

   (b) *Define an integral domain with an example. Show that every field is an integral domain but not conversely, justify.*

   (c) *Define Maximal Ideal with an example. State and prove the necessary and sufficient condition under which a quotient ring with unit element becomes a field.*

5. (a) *Define embedding with an example. State and prove embedding theorem.*

   (b) *Define Euclidean domain. Is ring of Gaussian integers an Euclidean domain? Justify. Show that every E.D has a unit element.*

   (c) *Define unique factorization domain with an example. Show that every Euclidean domain or a principal ideal domain is a unique factorization*

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Roll No:....................................

First Semester

End Term Examination

M. Sc.

November, 2019

MSMA-103, Real Analysis

Time: 3 Hours

Max. Marks: 100

Note: Attempt any five and all questions carry equal marks.

(1) (a) Define pseudo-metric space with example. Let (X, ρ) be any metric space then show that the function ρ^* defined by

$$\rho^*(x, y) = \frac{\rho(x, y)}{1 + \rho(x, y)}, \quad \forall x, y \in X$$

is a metric on X.

(b) Define open set and open sphere and show that each open sphere is an open set in a metric space (X, ρ).

(2) (a) Let (Y, ρ_Y) be a subspace of a metric space (X, ρ) and $A \subset Y$. Then prove that $x \in Y$ is a limit point of A in Y if and only if x is a limit point of A in X.

(b) Let (X, ρ_x) and (Y, ρ_Y) be two metric spaces. Then prove that a sequence $\{(x_n, y_n)\}$ in the product metric space $(X \times Y, \rho)$ converges to (x, y) if and only if the sequence $\{x_n\}$ converges to x in X and $\{y_n\}$ converges to y in Y.

(3) (a) Define complete metric space. If (X, ρ) is a complete metric space and Y is a subspace of X, then show that Y is complete iff Y is closed in X.

(b) Explain the Cantor set with example and show that a complete metric space is of second category.

(4) (a) What is a Lipschitz constant? State and prove Banach Contraction Theorem.

(b) Explain Finite Intersection Property(FIP) with example. Show that a metric space (X, ρ) is compact iff every family $\{F_\alpha : \alpha \in \Lambda\}$ of closed subsets of X such that $\bigcap_{\alpha \in \Lambda} F_\alpha \neq \phi$ contains a finite subfamily whose intersection is also non-empty.

(5) (a) Prove that a metric space (X, ρ) is sequentially compact iff every infinite subset of X has an accumulation point in X.

(b) Show that a compact subset of a metric space is closed.

(6) (a) Show that a totally bounded metric space is separable.

(b) Let (X, ρ_x) and (Y, ρ_y) be two metric spaces, then prove that a sequence $\{(x_n, y_n)\}$ is Cauchy in the product metric space $(X \times Y, \rho)$ if and only if $\{x_n\}$ and $\{y_n\}$ are Cauchy sequences in X and Y, respectively.

(7) (a) If Y is a connected subset of the metric space (X, ρ_X), then show that

(*i*) if $Y \subset A \cup B$, where A and B are separated sets in X, then either $Y \subset A$ or $Y \subset B$;

(*ii*) if Z is a subset of X such that $Y \subseteq Z \subseteq \overline{Y}$, then Z is connected.

(b) Show that a non-empty subset Y of a metric space (X, ρ_X) is disconnected iff there exists closed sets G_1 and G_2 in X with the following properties:

(*i*) $G_1 \cap Y \neq \phi$;

(*ii*) $G_2 \cap Y \neq \phi$;

(*iii*) $(G_1 \cap G_2) \cap Y = \phi$;

(*iv*) $Y \subseteq G_1 \cup G_2$.

(8) (a) If $f : [a, b] \to \mathbb{R}$ is differentiable on $[a, b]$, and $f' \in \mathcal{R}[a, b]$, then show that

$$\int_a^b f'(x)dx = f(b) - f(a).$$

(b) If $f : [a, b] \to \mathbb{R}$ is monotonic function, then show that

$$\int_a^b f(x)dx = f(a)(\xi - a) + f(b)(b - \xi), \quad a \leqslant \xi \leqslant b.$$

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Total No. of Pages : 02

Ist Semester — END SEMESTER EXAMINATION — M.Sc. (Math)

PAPER CODE : MSMA-105 — DECEMBER-2019

TITLE OF PAPER - Ordinary Differential Equation

TIME: 03 HRS.

MAX. MARKS: 100

Note : Attempt any five questions. Each question carry equal marks. Write legibly, avoid over-writing and unnecessary cutting. Assume suitable missing data, if any.

1. (a) For the initial value problem (IVP) $y' = 1 + y^2$, $y(0) = 0$. Find the largest interval $|x| \leq h$ on which the solution exists uniquely. Find also the unique solution and show that it actually exists over a larger interval than that guaranteed by the Picard's theorem. (5)

   (b) For integer $\nu = n$ show that $J_{-n}(x) = (-1)^n J_n(x)$, $n = 1, 2, \ldots$ (5)

   (c) Find a unique normalized homogeneous linear differential equation of order two which has $f_1(t) = t$ and $f_2(t) = te^t$ as a fundamental set of solution over some interval $a \leq t \leq b$. (5)

   (d) Determine the nature of the critical point $(0, 0)$ of the system (5)

$$\frac{dx}{dt} = 2x + 4y, \quad \frac{dy}{dt} = -2x + 6y.$$

   Also determine whether or not the point is stable.

2. (a) Let $f_1, f_2, \ldots f_n \in C^{n-1}(I)$ be n real valued linearly dependent functions. Then show that $W[f_1, f_2, \ldots f_n](t) = 0$ for all $t \in I$. Is the converse true? Give reasons in support of your answer. (10)

   (b) Find an equivalent integral equation corresponding to the IVP (10)

$$y''(t) - 2ty'(t) - 3y(t) = 0, \quad y(0) = 1, \quad y'(0) = 0.$$

3. (a) Show that the Legendre polynomials are given by (10)

$$P_n(x) = \frac{1}{2^n n!} \frac{d^n}{dx^n}(x^2 - 1)^n; \quad n = 0, 1, 2, 3 \ldots$$

(b) Solve $x^2y'' + xy' + (x^2 - \nu^2)y = 0$ to obtain Bessel function of first kind of order $\nu \geq 0$. (10)

4. (a) State and prove Abel-Liouville formula for homogeneous vector differential equations. (10)

(b) Find a unique solution ϕ of the non-homogeneous differential equation (10)

$$\frac{d\mathbf{x}}{dt} = \begin{pmatrix} 6 & -3 \\ 2 & 1 \end{pmatrix} \mathbf{x} + \begin{pmatrix} e^{5t} \\ 4 \end{pmatrix} \text{ such that } \phi(0) = \begin{pmatrix} 9 \\ 4 \end{pmatrix}.$$

5. (a) Consider the equation $\frac{d^2x}{dt^2} + q(t)x = 0$ where q is continuous on $a \leq t \leq b$ and such that $0 < m < q(t) < M$. Let ϕ_1 be a solution having consecutive zeros at t_1 and t_2 $(a \leq t_1 < t_2 \leq b)$. Show that (10)

$$\frac{\pi}{\sqrt{M}} < t_2 - t_1 < \frac{\pi}{\sqrt{m}}.$$

(b) Find the characteristic values and characteristic functions of the Sturm-Liouville problem $\frac{d}{dx}\left[x\frac{dy}{dx}\right] + \frac{\lambda}{x}y = 0;\ y'(1) = 0,\ \ y'(e^{2\pi}) = 0$ where parameter λ is nonnegative. (10)

6. (a) Let f and g be linearly independent solutions of $\frac{d}{dx}\left[P(t)\frac{dx}{dt}\right] + Q(t)x = 0$ on $a \leq t \leq b$. Then, show that between any two consecutive zeros of f there is precisely one zero of g. (10)

(b) If the roots of the characteristic equation of the linear system of two first order differential equations are real, distinct, and of the same sign. Show that the critical point $(0, 0)$ is a node. (10)

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Total No. of pages. 03 | Roll No....................

FIRST SEMESTER | M.Sc. (MATHEMATICS)

END SEMESTER EXAMINATION | **NOV/DEC 2019**

MSMA- 107 DISCRETE MATHEMATICS

Time: 3 Hours | **Max.Marks: 100**

Note: Answer **ALL** by selecting any **TWO** parts from each question. All questions carry equal marks.

Q1(a) A group G is isomorphic to a group H if there exists an isomorphism of G onto H. Let S be any family of groups. Then show that the relation "is isomorphic to" is an equivalence relation on S.

(b) Define equivalent compound statements. Show that

$$(P \rightarrow (Q \vee R)) \equiv ((P \rightarrow Q) \vee (P \rightarrow R))$$

(c) Define characteristic function of a set. Prove the following:

(i) $\chi_A(x) \leq \chi_B(x)\ iff\ A \subseteq B$

(ii) $\chi_{A\cap B}(x) = \chi_A(x).\chi_B(x)$

(iii) $\chi_{A\cup B}(x) = \chi_A(x) + \chi_B(x) - \chi_{A\cap B}(x)$

Q2(a) Find the total solution of the recurrence relation

$$a_n - 5a_{n-1} + 6a_{n-2} = 2^n + 3n,\ a_0 = 1, a_1 = 6$$

(b) (i) Suppose a class room has 8 rows of chairs, each row having 6 seats. If there are 41 students in the class, show that some row contains at least 6 students and some column contains at least 7 students.

(ii) There is a direct flight from Trichy to Delhi and two direct trains. There are 6 trains from Trichy to Chennai and 4 trains from Chennai to Delhi. Also there are 2 trains from Trichy to Mumbai and 8 flights from Mumbai to Delhi. In how many ways can a person travel from Trichy to Delhi?

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(c) Using generating function, solve the recurrence relation
$a_n - a_{n-1} - 6a_{n-2} = 0,\ a_0 = 2, a_1 = 1$

Q3(a) Define Lattice as a Poset and also as an algebraic structure. Show that these two definitions are equivalent.

(b) let L be a lattice then show that
(i) If $a \le b$ and $c \le d,\ a, b, c, d \in L$ then $a.c \le b.d$
(ii) $\forall a, b, c \in L, a.(b + c) \ge a.b + a.c$

(c) Let $f: L \to M$ be a lattice isomorphism, then show that
(i) If S is a sublattice of L then f(S) is a sublattice of M.
(ii)If T is a sublattice of M then $f^{-1}(T)$ is a sublattice of M.

Q4(a) Define Boolean algebra. Show that the following are equivalent in a Boolean algebra:
(i) a + b = b (ii) $a.b = a$ (iii) $a.b' = 0$ (iv) $a' + b = 1$

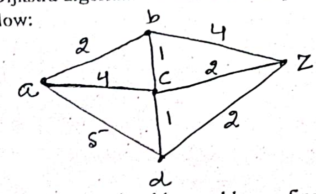
(b) Obtain the sum-of-products of the following Boolean expressions in x_1, x_2, x_3.

(i) $[(x_1x_2)x_3]\,[(x_1 + x_3)(x_2 + x_3)]$

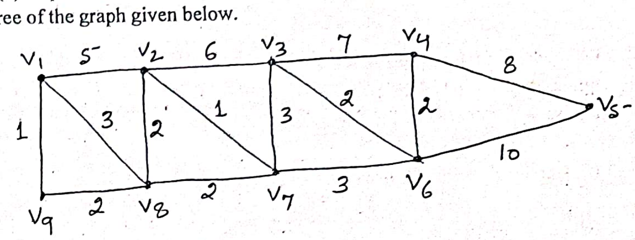
(ii) (x_2x_3)

(c) Let L be the set of all divisors of 4 and M be the set of all divisors of 9. $a \le b$ in L and M means a divides b. Then L and M both are lattices. Find L x M. Is this a distributive lattice? Justify your answer.

Q5 (a) Apply Dijkstra algorithm to find shortest path from a to z in the graph given below:



(b) Explain Krukskal's algorithm and hence find a minimal spanning tree of the graph given below.



(c) Prove that a simple graph with n vertices and k components can have at most (n-k)(n-k+1)/2 edge.

Total pages: 2 Roll No: ....

FIRST SEMESTER **M.Sc. Mathematics**

End Semester Exam, Nov. 2019

Code & Title: MSMA-109 Mathematical Statistics

Time: 3 Hrs. Max. Marks : 75

Note : Answer all questions, selecting two parts out of the three set. All questions carry equal marks. Assume suitable missing data, if any.

1(a) State and prove addition theorem of probability for n events and illustrate its application by considering a suitable example.

(b) Suppose that 3 batteries are randomly chosen from a group of 3 new, 4 used but still working, and 5 defective batteries. If X and Y denote the number of new and used but still working batteries chosen, then find the joint and marginal distributions. Are the two variables independent? Justify.

(c) State and prove Bay's theorem. Illustrate its application by considering a suitable example.

2(a) Define *Cov(X,Y)* between two random variables. Show that it is zero when the variables are independent. What about the converse? Prove that:

(i) $Cov(X, Y+Z) = Cov(X,Y) + Cov(X,Z)$

(ii) $Var[aX+bY] = a^2 Var(X) + b^2 Var(Y) + 2ab\, COV(X,Y)$

(b) State and prove weak law of large numbers. Illustrate its application by considering a suitable example.

(c) Differentiate between the problem of correlation and regression. Why are there two regression lines and where do they intersect? Find the angle of intersection and interpret results obtained for r = 0, 1 and -1.

3(a) Define binomial variate. Find its m.g.f. about mean. Hence find the coefficient of skewness and kurtosis. Analyse its behaviour as the number of trials tends to infinity.

(b) Suppose that from a population of N elements of which M are defective and N-M are non-defective, a sample of size k is drawn without replacements. What is the probability that the sample contains exactly k defectives? Find the mean and variance of the defectives.

(c) Define standard normal variate. What are the chief characteristics of its probability curve? Prove any two of those characteristics. For a normal distribution the first moment about 10 is 40 and the fourth moment about 50 is 48. Find its mean and variance.

4(a) Differentiate between 'statistics' and 'parameters'. Prove that in case the sampled population is normal, the distribution of the sample mean is exactly normal irrespective of the sample size, however, if the population is non-normal then its distribution is approximately normal.

(b)(i) What is hypothesis testing? Describe the two types of errors which arise in testing.

(ii) Define t-variate and show that in limiting case it tends to a normal variate.

(c)(i) If X and Y are two independent Chi-square variates respectively with n and m degrees of freedom, then find the distribution of X+Y.

(ii) What is Chi-square test of 'goodness-of-fit'? Illustrate its application by considering a suitable example of your choice.

5(a) What do you understand by estimation? Describe the characteristics of a good estimator. If a random sample $x_1, \ldots, x_n$ is drawn from a Bernoulli population with parameter α, then show that $\frac{[(\Sigma x)(\Sigma x-1)]}{n(n-1)}$ is an unbiased estimate of α^2.

(b) Explain the method of maximum likelihood estimation. What are the important properties of MLE's? Find the MLE of the parameter α of a population having density function $f(x) = 2(\alpha - x)/\alpha^2$, $0 < \alpha < x$ for a sample of size n = 1. Show that the estimate obtained is biased. What is the unbiased estimate of the parameter for unit sample size.

(c)(i) State and prove sufficient condition for consistency.

(ii) What are MVB estimators? Obtain the MVB estimator for the population mean of a normal population when its variance is known.

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Total No. of Pages: 2

FIRST SEMESTER

END SEMESTER EXAMINATION

Roll No.........

M.Sc. Physics

Nov. 2019

MSPH-101: MATHEMATICAL PHYSICS

Time: 3 Hours *Max. Marks: 100*

Note: Attempt *Any Five* questions.
Assume suitable missing data, if any.

1. (i) Evaluate the following integral, where C is the ellipse $9x^2 + y^2 = 9$. (10)

$$\oint_C \left(\frac{ze^{\pi z}}{z^4 - 16} + ze^{\pi/z} \right) dz$$

(ii) Evaluate $\int_0^{2\pi} \frac{d\theta}{a+b\sin\theta}$ if $a > |b|$. (10)

2. (i) Verify the divergence theorem for the function $\vec{F} = 2x^2y\,\hat{\imath} - y^2\hat{\jmath} + 4xz^2\hat{k}$ taken over the region in the first octant bounded by $y^2 + z^2 = 9$ and $x = 2$. (10)

(ii) Prove that $\vec{F} = r^2\vec{r}$ is conservative and find the scalar potential ϕ such that $\vec{F} = \nabla\phi$. (10)

3. (i) Show that $U = W$, where U and W are the following subspace of R^3

$U = span\ (u_1, u_2, u_3) = span\ \{(1,1,-1),(2,3,-1),(3,1,-5)\}$

$W = span\ (w_1, w_2, w_3) = span\ \{(1,-1,-3),(3,-2,-8),(2,1,-3)\}$ (6)

(ii) Let $F: R^4 \rightarrow R^3$ be the linear mapping defined by

$$F(x,y,z,t) = (x - y + z + t, x + 2z - t, x + y + 3z - 3t)$$

Find a basis and the dimension of (a) the image of F, (b) the kernel of F. (10)

(iii) Find the conditions on a, b, c so that $v = (a,b,c)$ in R^3 belongs to $U = span\ (u_1, u_2, u_3)$ where $u_1 = (1,2,0)$, $u_2 = (-1,1,2)$ and $u_3 = (3,0,-4)$. (4)

4. (i) Show that following is an inner product on R^2:

$\langle u,v \rangle = x_1y_1 + x_1y_2 + x_2y_1 + 2x_2y_2$, where $u = [x_1, x_2]$ and $v = [y_1, y_2]$.

Also find the norm of $u = [2,3]$ with respect to the given inner product on R^2. (10)

(ii) Let V be the subspace of R^4 spanned by $v_1 = (1,1,1,1)$, $v_2 = (1,-1,2,2)$ and $v_3 = (1,2,-3,-4)$. Apply the Gram-Schmidt algorithm to find an orthogonal and an orthonormal basis for U. (10)

5. (i) Show that the set of all positive rational numbers Q forms an abelian group under the composition defined by

$$a * b = \frac{(ab)}{2}. \tag{10}$$

(ii) Prove that those elements of a group G which commute with the square of a given element b of G form a subgroup H of G and those which commute with b itself form a subgroup of H. Set $H = \{x \in G: xb^2 = b^2x\}$ and Set $N = \{y \in G: yb = by\}$ (10)

6. (i) Let I be the set of all integers and let R be the relation defined in I, such that xRy holds iff $(x - y)$ is divisible by 5, $x \in I$, $y \in I$, i.e. $R = \{(x, y) : x \in I, y \in I, (x - y)$ is divisible by $5\}$. Show that R is an equivalence relation in I and determine all the possible equivalence classes in the set I with respect to relation R. (10)

(ii) If $\vec{a}$ is a constant vector, show that $\vec{a} \times (\vec{\nabla} \times \vec{r}) = \vec{\nabla}(\vec{a}.\vec{r}) - (\vec{a}.\vec{\nabla})\vec{r}$ where $\vec{a} = a_1\hat{\imath} + a_2\hat{\jmath} + a_3\hat{k}$ and $\vec{r} = r_1\hat{\imath} + r_2\hat{\jmath} + r_3\hat{k}$. (10)

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Total No. of Pages: 2

FIRST SEMESTER **Roll No........**

END SEMESTER EXAMINATION **M.Sc Physics**

Nov. *2019*

MSPH-103: CLASSICAL MECHANICS

Time: 3 Hours ***Max. Marks: 100***

Note: Q1. is compulsory. Attempt *Any four from the remaining* questions.
Assume suitable missing data, if any.

1. **(i)** Two heavy particles of weights W_1 and W_2 are connected by a light inextensible string and hang over a fixed smooth circular cylinder of radius R, the axis of which is horizontal. Find the condition of equilibrium of the system by applying the principle of virtual work.

(ii) Show that if a coordinate corresponding to rotation is cyclic, angular momentum of the system is conserved.

(iii) If F and G are functions of position co-ordinates q_i and momentum co-ordinates p_i, define the Poisson's brackets of F and G. Prove that (a) $[F,G] = -[G,F]$ and

(b) $[q_i, p_j] = -\delta_{ij}$

(iv) What is a four vector? Show that scalar product of two four vectors is invariant under Lorentz transformations.

(v) Find the equation of motion of one dimensional harmonic oscillator using Hamilton's Principle.

(4 x 5 = 20)

2. (i) Obtain Euler Lagrange differential equation of motion using Variational method. Also Find an equation of the curve which on revolving about a certain axis forms geometry of minimum surface area. (10)

(ii) A bead slides on a wire in the shape of a cycloid described by equations

$$x = a(\theta - \sin\theta)$$
$$y = a(1 + \cos\theta)$$

where $0 \leq \theta \leq 2\Pi$. Find (a) Lagrangian function (b) equation of motion. Neglect friction between bead and the wire. (10)

3. (i) If the transformation equations between two sets of coordinate are

$$P = 2\sqrt{q}\,(1 + \sqrt{q}\cos p)\sin p$$
$$Q = \log(1 + \sqrt{q}\cos p),$$

then show that (a) the transformation is canonical and (b) Determine the generating function $F(p,Q)$. (10)

(ii) Define Poisson bracket of two dynamical variables. Show that for any three dynamical variables, u, v, w the Jacobi identity $[u,[v,w]] + [v,[w,u]] + [w,[u,v]] = 0$ is satisfied.(10)

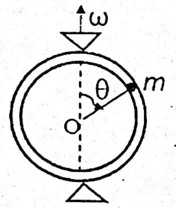
4. (i) What is differential scattering cross-section? Discuss the problem of charged particles by a coloumb field and obtain Rutherford's formula for differential scattering cross-section. (10)

(ii) Derive the differential equation of the orbit in polar coordinates under a central force. Investigate motion of the particle moving under an attractive inverse square law. Also find the central force under the action of which a particle will follow an orbit described by $r = a(1+\cos\theta)$. (10)

5.(i) What is Minkowski space? Show that the Lorentz transformations can be regarded as transformations due to a rotation of axes in the four – dimensional Minkowski space. Hence deduce the Lorentz transformation. (10)

(ii) A hundred μ mesons, each of rest mass 206 electrons and energy 4.75 BeV are produced at an altitude of 30 km. If the mean life of μ mesons is 2.2×10^{-6} seconds, calculate their number expected to reach the sea level (a) allowing for time dilation and (b) neglecting time dilation. Given the rest mass = 0.5MeV. What conclusion can you draw from your result. (10)

6. (i) A particle of mass m can slide without friction on the inside of a small tube which is bent in the form of a circle of radius r. the tube rotates about a vertical diameter with a constant angular velocity ω and has a moment of inertia I about this axis. Find the Hamiltonian and obtain Hamilton's equations of motion for this system. (10)



(ii) Derive Hamilton's canonical equations of motion. Obtain Hamiltonian and Hamilton's equation of motion of a charged particle in an electromagnetic field. (10)

Total No. of Pages: 4
FIRST SEMESTER
END SEMESTER EXAMINATION

Roll No……………
M.Sc. Physics
Nov. 2019

MSPH-105: QUANTUM MECHANICS

Time: 3 Hours **Max. Marks: 100**

Important Notes:
i) There are total nine (9) questions.
ii) You have to attempt five (5) questions.
iii) Question No. 1 is compulsory.
iv) Except question No. 1, remaining all have an internal choice.
v) Assume suitable missing data, if any.

Q1. (a) Demonstrate that the norm of the state vector evolving from the Schrödinger equation remains constant. **(4)**

(b) Show that the Hermitian character of a matrix remains unchanged under transformation by a Unitary matrix. **(4)**

(c) Prove that $[L^2, L]=0$ and $\vec{L}\times\vec{L}=i\hbar\vec{L}$, where $\vec{L}$ is the orbital angular momentum operator. **(4)**

(d) Discuss the physical meaning of matrix element corresponding to a quantum mechanical operator. **(4)**

(e) Discuss Pauli's exclusion principle in the light of anti-symmetric and symmetric wave functions. **(4)**

Q2. (a) Solve the time-independent Schrödinger equation for the Infinite Square Well Potential (Asymmetric Square Well) and plot the first three states of this infinite potential well. Also comment on zero-point energy. **(15)**

(b) In continuation of above, to illustrate the idea that the zero-point energy gets larger by going from macroscopic to microscopic systems, calculate the zero-point energy for a particle in an infinite potential well for the following cases:

(i) A 100 g ball confined on a 5 m long line,

(ii) An oxygen atom confined to a 2×10^{-10} m lattice, and
(iii) An electron confined to a 10^{-10} m atom. **(5)**

OR

Q3. Consider a one-dimensional bound particle.

(i) Show that

$$\frac{d}{dt}\int_{-\infty}^{+\infty}\psi^*(x,t)\psi(x,t)dx=0 \quad (\psi \text{ need not be a stationary state})$$

(ii) Show that, if the particle is in a stationary state at a given time, then it will always remain in a stationary state.

(iii) If at $t=0$ the wave function is constant in the region $-a<x<a$ and zero elsewhere, express the complete wave function at a subsequent time in terms of the eigenstates of the system. **(20)**

Q4. (a) Discuss Heisenberg picture in detail and show that $\frac{d\Omega_H}{dt}=\frac{\partial\Omega_H}{\partial t}+\frac{1}{i\hbar}[\Omega_H, H_H]$. **(15)**

(b) Consider a state $|\psi\rangle=\frac{1}{\sqrt{2}}|\phi_1\rangle+\frac{1}{\sqrt{5}}|\phi_2\rangle+\frac{1}{\sqrt{10}}|\phi_3\rangle$ which is given in terms of three orthonormal eigenstates $|\phi_1\rangle, |\phi_2\rangle$, and $|\phi_3\rangle$ of an operator $\hat{A}$ such that $\hat{A}|\phi_n\rangle=n^2|\phi_n\rangle$. Find the expectation value of $\hat{A}$ for the state $|\psi\rangle$. **(5)**

OR

Q5. (a) Workout for the equation of motion for a physical system which evolves in time in such a manner that both the state vectors and the dynamical variable of the system is time dependent. **(15)**

(b) Let the Hamiltonian for a system be given by:

$$\hat{H}=\begin{pmatrix}\varepsilon_1 & \varepsilon_2\\ \varepsilon_2 & \varepsilon_1\end{pmatrix},$$

where ε_1 and ε_2 are constants of the dimensions of energy. Find the eigenvalues and the corresponding eigenvectors of $\hat{H}$ and, thus, set up the basis in the state space of the system. **(5)**

Q6. (a) If $|\lambda, m\rangle$ is a simultaneous eigenket of operator J^2 and J_z then $J_\pm|\lambda, m\rangle$ will be simultaneous eigenket of J^2 and J_z with eigenvalues λ and $(m \pm 1)$ respectively, where $J_\pm$ are called Ladder Operators. This statement can be expressed, mathematically, as:

$$J_\pm|\lambda, m\rangle = C_\pm|\lambda, m \pm 1\rangle.$$

Evaluate the constants $C_\pm$. **(12)**

(b) Verify the following commutation relation:

$$[J^2, J_z] = 0$$ **(8)**

OR

Q7. (a) Evaluate the Clebsch-Gordan (CG) coefficients for $j_1 = \frac{1}{2}$ and $j_2 = \frac{1}{2}$, and write the corresponding matrix. **(12)**

(b) Consider a system of three non-interacting identical spin ½ particles that are in the same spin state $\left|\frac{1}{2}, \frac{1}{2}\right\rangle$ and confined to move in a one-dimensional infinite potential well of length a: $V(x) = 0$ for $0 < x < a$ and $V(x) = \infty$ for other values of x. Determine the energy and wave function of the ground state, the first excited state, and the second excited state. **(8)**

Q8. (a) Discuss briefly the basic principle of Variational method and use this method to estimate the ground state energy of the hydrogen atom. **(15)**

(b) Calculate the first-order correction to the ground state energy of an anharmonic oscillator of mass m and angular frequency ω subjected to a potential:

$$V(x) = \frac{1}{2}m\omega^2 x^2 + bx^4,$$

where b is a parameter independent of x. The ground state wave function is

$$\psi_0^0 = \left(\frac{m\omega}{\pi\hbar}\right)^{1/4} \exp\left(-\frac{m\omega x^2}{2\hbar}\right)$$ **(5)**

OR

Q9. (a) Give a brief description of time-dependent perturbation theory. Derive and discuss the transition probabilities for stimulated emission and absorption (case of harmonic perturbation only). **(15)**

(b) Explain Fermi's golden rule. **(5)**

7. Consider a plane wave incident normally on a rectangular aperture of width 'b' (along the ξ axis) and width 'a' (along the η axis) placed on the aperture plane i.e.

$$U(\xi,\eta,0) = A \quad |\xi|< b/2 \text{ and } |\eta|< a/2$$
$$= 0 \quad \text{everywhere else}$$

for all values of η. Calculate the corresponding Fraunhoffer diffraction. [12]

8. Analyze using Fresnel integrals the diffraction of a plane wave incident normally on a long narrow slit. Further analyze the transition of Fresnel diffraction to Fraunhoffer diffraction. [12]

9. (a) Explain Cornu's spiral indicating its salient features.

(b) Consider a straight edge being illuminated by parallel beam of light with wavelength 0.6 µm. Calculate the positions of the first two maxima and minima on a screen at a distance of 50 cm from the edge. Also, find the corresponding values of intensity (I/I_0). [4,8]

Table for Fresnel integrals is given below.

Fresnel Integrals

s	$C(s)$	$S(s)$
0.0	0.000	0.000
0.2	0.200	0.004
0.4	0.398	0.033
0.6	0.581	0.111
0.8	0.723	0.249
1.0	0.780	0.438
1.2	0.715	0.623
1.4	0.543	0.714
1.6	0.366	0.638
1.8	0.334	0.451
2.0	0.488	0.343
2.5	0.457	0.619
3.0	0.606	0.496
3.5	0.533	0.415
4.0	0.498	0.420
∞	0.500	0.500

Total No. of Pages:4 Roll No. ......

FIRST SEMESTER M.Sc.(Physics)

END SEMESTER EXAMINATION ***(Nov.-2019)***

MSPH107 - APPLIED OPTICS

Time:3Hours **Max. Marks: 100**

Note: Question No. 1 is compulsory.

Answer any seven questions from Q.No.2 to Q.No.9

1. (a) Show that in the limit $\theta_1 \rightarrow 0$ (i.e. at normal incidence) the reflection coefficient is the same for parallel and perpendicular polarizations.

(b) Describe Goos –Hanchen shift.

(c) It is not possible to show interference effects between light from two separate sodium vapour lamps but you can show interference effects between sounds from loudspeakers that are driven by separate oscillators. Explain why it is so.

(d)Determine the refractive index and thickness of the film to be deposited on a glass surface ($n_g = 1.54$) such that no normally incident light of wavelength 540nm is reflected.

(e) Plot the function '$\text{Sin}^2 N\gamma / \text{Sin}^2 \gamma$' for N = 5.

(f) In the Michelson interferometer arrangement, if one of the mirrors is moved by a distance 0.08mm, 250 fringes cross the field of view. Calculate the wavelength.

(g) A particular laser is operating in single mode and emitting a continous wave lasing emission whose spectral width is 1 MHz. What is the coherence time and coherence length?

(h) A grating with 200 lines per millimetre and of width 2cm is fully illuminated by light consisting of wavelengths 600 nm and 600.1 nm. What is the lowest diffraction order where two wavelengths will be resolved? [2*8=16]

1-41-

2. (a) An EM wave travels in free space with the electric field component

$E_s = 100\, e^{j(0.866y+0.5z)} a_x$ V/m

Determine (i) ω and λ (ii) The magnetic field component (iii) The average time power in the wave.

(b) A lossy dielectric has an intrinsic impedance of $200e^{j\pi/6}\ \Omega$ at a particular radian frequency ω. If at that frequency, the plane wave propagating through the dielectric has the magnetic field component

$H = 10\, e^{-\alpha x} \cos\left(\omega t - \frac{x}{2}\right) a_y$ A/m

Find **E** and α. Determine the skin depth and wave polarization. [6,6]

3. Consider a linearly polarized electromagnetic wave (with its electric vector along the y direction of magnitude 5V/m) propagating in vacuum. It is incident on a dielectric interface at x = 0 at an angle of incidence of 30^0. The frequency associated with the wave is 6 X 10^{14} Hz. The refractive index of the dielectric is 1.5. Write the complete expressions for the electric and magnetic fields associated with the incident, reflected and transmitted waves. [12]

4. a) In the Newton's rings arrangement, if the incident light consists of two wavelengths 4000 A^0 and 4002 A^0 calculate the distance (from the point of contact)at which the rings will disappear. Assume that the radius of curvature of the curved surface is 400 cm.

If the lens is slowly moved upwards, calculate the height of the lens at which the fringe system (around the center) will disappear.

(b) A Fabry Perot interferometer is to be used to resolve the mode structure of a He- Ne laser operating at 632.8 nm. The frequency separation between the modes is 150 MHz. The plates are separated by an air gap and have a reflectance (r^2) of 0.999.

(i) What is the coefficient of finesse of the instrument?

(ii)What is the resolving power required?

(iii) What plate spacing is required?

(iv) What is the free spectral range of the instrument under these conditions?

(v) What is the minimum resolvable wavelength interval under these conditions? [6,6]

5. (a) Plane waves of monochromatic light (600 nm) light are incident on an aperture. A detector is situated on axis at a distance of 20 cm from the aperture plane.

(i) What is the value of R_1, the radius of the first Fresnel half period zone, relative to the detector?

(ii) If the aperture is a circle of radius 1cm, centered on axis, how many half period zones does it contain?

(iii) If the aperture is a zone plate with every other zone blocked out and with radius of the first zone equal to R_1 (found in (i)), determine the first three focal lengths of the zone plate.

(b) A single square pulse of amplitude A and duration τ_0 is represented by

$$f(t) = \begin{cases} A & -\frac{\tau_0}{2} < t < -\frac{\tau_0}{2} \\ 0 & elsewhere \end{cases}$$

Using Fourier transform, determine and sketch the power spectrum, locating its zeros. Show that the frequency bandwidth for the pulse is inversely proportional to its duration. [6,6]

6. Consider a Gaussian beam propagating along the z direction whose amplitude distribution on the plane z = 0 is given by

$$A(\xi,\eta,0) = A\, exp[\frac{-\xi^2 + \eta^2}{w_0{}^2}]$$

Obtain the expression for the intensity of the propagating beam.

(b) A Gaussian beam is coming out of a laser. Assume λ = 600 nm and that at z =0, the beam width is 1mm and the phase front is plane. After traversing 10m through vacuum what will be (i) beam width and (ii) the radius of curvature of the phase front. [8, 4]

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Total No of Pages: 2
Semester-I
End Semester Examination

Roll No................
M.Sc Physics
December -2019

MSPH109: Electronics

Time: 3:00 Hours **Max Marks-100**

Note: Question 1 is compulsory. Attempt any four questions out of remaining five.

Q1. **Answer the following questions:** (20)

(a) In voltage divider bias configuration of BJT, operating point is at 3V, 2mA. If V_{CC} = 9V, R_C= 2.2 KΩ what is the value of R_E?
i) 2000 Ω ii) 1400 Ω iii) 800 Ω iv) 1600 Ω

(b) If the cross-sectional area of the channel in n-channel JFET increases, the drain current.........
i) is increased ii) is decreased iii) remains the same iv) none of these

(c) The output of a particular OP-AMP increases 8V in 12μs. The slew rate is ....
i) 90V/μs ii) 0.67V/μs iii) 1.5V/μs iv) none of these

(d) If A_{DM} =3500 and A_{CM}= 0.35, the CMRR is ....
i) 1225 ii) 10,000 iii) 80 dB iv) answer (ii) and (iii)

(e) Write the excitation table of RS flip-flop.

Q2 (a) What is difference between JFET and BJT and also determine the drain characteristics of JFET. Also draw the symbol for P-type and N-type JFET. Sketch the transfer curve define by I_{DSS} = 12 mA and V_P= - 6V. (12)

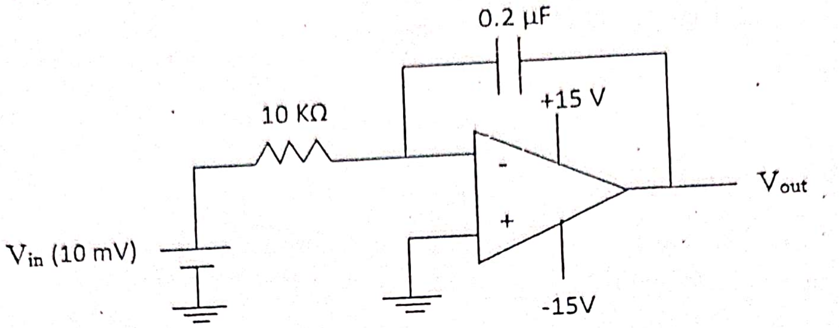
(b) Name the three possible transistor configurations and compare their input and output characteristics with circuit diagram and also find the relation between their current gains. (8)

Q3 (a) What is an operational amplifier. State the ideal characteristic of an operational amplifier. Discuss the OP-AMP as an inverting amplifier with negative feedback and derive the expression for its gain. (12)

(b) A three-stage OP-AMP circuit is required to provide voltage gains of +10, -18, and -27. Design the OP-AMP circuit. Use a 270 KΩ feedback resistor for all three circuits. What output voltage will result for an input of 150 μV. (8)

R.T.O

Q4 (a) Explain the working of OP-AMP as an integrator and derive the expression for the output voltage (V_O) for a given input voltage (V_i). For the circuit given below, how long does it take for the output to reach saturation voltage and also draw the output? (12)



(b) Explain the operation of Shunt voltage regulator by using OP-AMP and also discuss the disadvantage of using zener diode as voltage regulator component. (8)

Q5 (a) What are the difference between Multiplexer and Demultiplexer? Realise Y=A'B+B'C'+ABC using an 8-to-1 multiplexer, can it be also realized with a 4- to-1 multiplexer. (12)

(b) What is decoder? Show how to convert a Decoder into Demultiplexer. Also, indicate how to add a strobe to this system. (8)

Q6 (a) What is a flip-flop? Explain the operation of a RS flip-flop. How does the master slave action in JK flip flop improve its operation? (12)

(b) What is characteristic equation of a flip-flop. Write the characteristic equation for JK flip flop. The waveform given below drives a clocked D latch. What is the value of D stored in the flip-flop after the clock pulse is over? (8)