2010

Syllabus and Sample Questions for JRF

AGRICULTURAL AND ECOLOGICAL RESEARCH UNIT

[Test Code: RAE]

The candidates have to take two tests: Test RAE I (objective type) in the forenoon session and test RAE II (short answer type) in the afternoon session. Both tests will comprise of two groups: Groups A and B (Group A for candidates having M.Sc. in Botany/Environmental Science and Group B for candidates having M. Sc. in Applied Mathematics/Statistics).
For both tests, Full Marks will be 100 and Time: 2 hours.

Syllabus

Group A

1. Structure, function and metabolism of carbohydrates, lipids, proteins, vitamins and minerals; nucleic acids; metabolic pathways; enzymes and coenzymes.

2. Respiration and photosynthesis; protein synthesis; growth promoting plant hormones, response to stress. Principles of taxonomy as applied to the systematics of classification of plant kingdom.

3. Mendelian genetics, recombination; DNA structure, replication, transcription, translation; DNA footprinting; control of gene expression; polymerase chain reaction; recent trends in molecular biology.

4. Ecosystem structure, food chain and energy flow, ecosystem diversity, productivity and biogeochemical cycles, limnology; environmental pollution, sustainable development, biodiversity, global change.

5. General laboratory analytical techniques and principles.

6. Basic Statistics and Computation : Descriptive statistics, correlation, simple regression, analysis of variance, Microsoft Excel.

Group B

1. Elementary set theory, finite, countable and uncountable sets, real number system as a complete ordered field, Archimedean property, supremum, infimum, sequences and series, convergence, limsup, liminf.

2. Algebra of complex numbers, the complex plane, polynomials, power series, transcendental functions such as exponential, trigonometric and hyperbolic functions, analytic functions, Cauchy-Riemann equations, contour integral, Cauchy's theorem, Cauchy's integral formula, Liouville's theorem.

3. Existence and uniqueness of solutions of initial value problems for first order ordinary differential equations, singular solutions of first order ODEs, system of

first order ODEs, general theory of homogenous and non-homogeneous linear ODEs, variation of parameters, Sturm-Liouville boundary value problem, Green's function.

4. Lagrange and Charpit methods for solving first order PDEs, Cauchy problem for first order PDEs, classification of second order PDEs, general solution of higher order PDEs with constant coefficients, method of separation of variables for Laplace, Heat and Wave equations.

5. Numerical solutions of algebraic equations, method of iteration and Newton-Raphson method, Rate of convergence, solution of systems of linear algebraic equations using Gauss elimination and Gauss-Seidel methods, finite differences, Lagrange, Hermite and spline interpolation, numerical differentiation and integration, numerical solutions of ODEs using Picard, Euler, modified Euler and Runge-Kutta methods.

6. Sample space, discrete probability, independent events, Bayes theorem, random variables and distribution functions (univariate and multivariate), expectation and moments, independent random variables, marginal and conditional distributions, characteristic functions, probability inequalities (Tchebyshef, Markov, Jensen), modes of convergence, weak and strong laws of large numbers, Central Limit theorems (i.i.d. case).

7. Birth-death process, Poisson process, stationary distribution.

8. Standard discrete and continuous univariate distributions, sampling distributions, standard errors and asymptotic distributions.

9. Methods of estimation, properties of estimators, confidence intervals, tests of hypotheses: most powerful and uniformly most powerful tests, likelihood ratio tests, Analysis of discrete data and chi-square test of goodness of fit, large sample tests.

10. Analysis of variance and covariance, fixed, random and mixed effects models, simple and multiple linear regression, logistic regression, Multivariate normal distribution.

11. Linear programming problem, simplex methods, duality.

12. Mathematical models on simple ecological and epidemiological systems, linear stability, bifurcation analysis, sigmoidal growth models, Stochastic growth curve analysis, longitudinal data analysis.

Sample Questions

[Forenoon session]

RAE I

GROUP A (Botany/Environmental Science)

Select the correct answer from the multiple choice:

1. In the process of photosynthesis, chlorophyll serves as

   (*i*) an end-product
   (*ii*) a raw material
   (*iii*) an energy converter
   (*iv*) a hydrogen acceptor

2. The synthesis of glucose from lactate, glycerol, or amino acids is called

   (*i*) glycogenolysis
   (*ii*) glycolysis
   (*iii*) lipolysis
   (*iv*) gluconeogenesis

3. Carotenoid plant pigments primarily absorb the following wavelengths of PAR

   (*i*) blue.
   (*ii*) green
   (*iii*) both blue and green
   (*iv*) neither blue or green

4. Kinase reactions:

   (*i*) involve the addition or removal of a ketone group
   (*ii*) involve the addition or removal of a phosphate group
   (*iii*) involve the transfer of hydrogen atoms
   (*iv*) involve the addition or removal of an amino acid to a polypeptide chain

5. One of the most significant discoveries which allowed the development of recombinant DNA technology was:

   (*i*) the discovery of DNA and RNA polymerase allowing workers to synthesize any DNA sequence.
   (*ii*) identification and isolation of restricted endonucleases permitting specific DNA cutting.
   (*iii*) the development of polymerase chain reaction.
   (*iv*) the Southern technique for separation and identification of DNA sequences.

6. Which group of algae is most likely to experience silica limitation?

(*i*) Euglenophycaeae.
(*ii*) Chlorophycaeae.
(*iii*) cyanobacteria.
(*iv*) Bacillariophycaeae.

7. Which of the following greenhouse gases has the greatest heat trapping ability per molecule?

(*i*) carbon dioxide
(*ii*) carbon monoxide
(*iii*) chlorofluorocarbon
(*iv*) methane

8. Buffer is a:

(*i*) weak acid and its salt
(*ii*) strong acid and weak
(*iii*) neutral
(*iv*) strong acid and its

9. The sample mean is an unbiased estimator for the population mean. This means:

(*i*) The sample mean always equals the population mean.
(*ii*) The average sample mean, over all possible samples, equals the population mean.
(*iii*) The sample mean is always very close to the population mean.
(*iv*) The sample mean will only vary a little from the population mean.

10. In Microsoft Excel, the cell reference for a range of cells that starts in cell B1 and goes over to column G and down to row 10 is:

(*i*) B1-G10
(*ii*) B1.G10
(*iii*) B1;G10
(*iv*) B1:G10

GROUP B (Applied Mathematics/Statistics)

1. If $x_1, x_2, \ldots, x_n$ are positive real numbers then

$$\frac{x_1}{x_2} + \frac{x_2}{x_3} + \ldots + \frac{x_n}{x_1}$$

is always

(a) $\geq n$,
(b) $\leq n$,
(c) $\leq n^{1/n}$,
(d) none of this

2. Standard deviation of scores in a paper of 100 marks cannot exceed

(a) 50,
(b) 25,
(c) $\sqrt{50}$,
(d) none of these

3. The inequality between mean and variance are in reverse order for which of the following pairs of distributions ?

(a) (binomial, Poisson),
(b) (binomial, negative binomial),
(c) (Poisson, negative binomial),
(d) none of these

4. Suppose $X_1, X_2, \ldots X_n$ are i.i.d. with density function

$$f(x) = \frac{\theta}{x^2} \ , \theta < x, \theta > 0$$

(a) $\sum_{i=1}^{n} \frac{1}{x_i^2}$ is sufficient for θ.
(b) $\min_{1 \leq i \leq n} x_i$ is sufficient for θ.
(c) $\prod_{i=1}^{n} \frac{1}{x_i^2}$ is sufficient for θ
(d) $(\max_{1 \leq i \leq n} x_i, \min_{1 \leq i \leq n} x_i)$ is not sufficient for θ

5. The series

$$\sum_{i=1}^{\infty} \frac{\sin nx}{n^2}$$

is

(a) Uniformly convergent
(b) only point wise convergent
(c) divergent
(d) none of these

6. The value of the integral $\int_C \frac{3z^{99}+1}{z^2-1}$ where C is the ellipse $x^2 + 2y^2 = 8$ described in the positive sense is

(a) 0
(b) $2\pi i$
(c) $4\pi i$
(d) $6\pi i$

7. The number of linearly independent solutions of the differential equation

$$\frac{d^4y}{dx^4} - \frac{d^3y}{dx^3} - 3\frac{d^2y}{dx^2} + 5\frac{dy}{dx} - 2y = 0$$

of the form e^{ax} (a is a real number) is

(a) 1
(b) 2
(c) 3
(d) 4

8. The complete integral of the partial differential equation

$$\frac{\delta z}{\delta x}\frac{\delta z}{\delta y} = 2xy$$

is

(a) $z = x^2 + y^2 + c$
(b) $z = \frac{1}{2}x^2 + y^2 + c$
(c) $z = x^2 - y^2 + c$
(d) $z = x^2y^2 + c$

9. Suppose [x] denotes the largest integer less than or equal to x and $\{x\}$ denotes the fractional part of x. Then which of the following relation is true for all x and y.

(a) $[x+y] \geq [x]+[y]$
(b) $[x+y] \leq [x]+[y]$
(c) $\{x+y\} \leq \{x\}+\{y\}$
(d) $\{x+y\} \geq \{x\}+\{y\}$

10. Consider the problem

$$\max\ 6x_1 - 2x_2$$

subject to

$$x_1 - x_2 \leq 1$$
$$3x_1 - x_2 \leq 6$$

$x_1,\ x_2 \geq 0.$

This problem has

(a) unbounded solution space but unique optimal solution with finite optimum objective value
(b) unbounded solution space as well as unbounded objective value
(c) no feasible solution
(d) unbounded solution space but infinite optimal solutions with finite optimum objective value

Sample Questions

[Afternoon session]

RAE II

[To be answered in separate answer script, not in the Question Paper]

Group A

Answer/solve each of the following questions

1. Describe and illustrate the important anatomical features and physiological processes that are required for stomatal opening. Clearly label the diagram and indicate the order in which events occur.

2. Write down the common and distinct features in enzymatic and non-enzymatic catalysts. Mention five important practical utility of enzymes.

3. What is Polymerase Chain Reaction? Can any DNA polymerase be used in PCR?

4. Inspite of the continued utilization of nitrogen by forest vegetation, the forest soil does not usually become depleted of its nitrogen content. How is this possible?

5. Describe three different plant strategies for dealing with environmental stress and provide one example for each of these strategies.

6. (a) Write down a sentence or two explaining the difference between:
(i) Populations and samples (ii) Correlation and regression
(b) The heights of 10 randomly selected plants, to the nearest tenth of a centimeter, are given below:

4.0 8.5 7.4 5.6 5.7 7.0 9.3 5.2 6.8 6.1

Calculate the sample mean and sample variance showing all your calculations.

Group B

Answer/solve question number 1 and any two from the rest.

1. A die is thrown repeatedly until all the faces appear. Find the probability that exactly n ($n \geq 6$) number of trials are required.

2. Let Y_1, Y_2 be two independent random variables each having exponential distribution with parameter λ. Then find the conditional distribution of Y_1 given $Y_1 + Y_2 = 1$.

3.Let X be a nonnegative random variable with distribution function F, then prove that

$$E[X] = \int_0^\infty (1 - F(x))dx$$

4. Find the singular solution of the differential equation satisfied by the family of curves $c^2 + 2cy - x^2 + 1 = 0$ where c is a parameter.

5. Prove that $f(z) = \frac{z-i}{z+i}$ maps the open upper half plane into the open unit disc. If g is an entire function with values in the open upper half plane, what is the range of $h = f \circ g$? Is h an entire function? If f is an entire function, what conclusion can be drawn about f and g?

6. Reduce the following equation to a canonical form.

$$u_{xx} - 2\sin(x)u_{xy} - \cos^2(x)u_{yy} - \cos(x)u_y = 0$$