Indian Forest Service Examination-2013

PHYSICS

Paper I

(CONVENTIONAL)

Time allowed : Three Hours | *Maximum Marks : 200*

Question Paper Specific Instructions

Please read each of the following instructions carefully before attempting questions :

*There are **EIGHT** questions in all, out of which **FIVE** are to be attempted.*

*Questions no. **1** and **5** are compulsory. Out of the remaining **SIX** questions, **THREE** are to be attempted selecting at least **ONE** question from each of the two Sections **A** and **B**.*

All questions carry equal marks. The number of marks carried by a part of a question is indicated against it.

*Answers must be written in **ENGLISH** only.*

Unless otherwise mentioned, symbols and notations have their usual standard meanings.

Assume suitable data, if necessary and indicate the same clearly.

Neat sketches may be drawn, wherever required.

All parts and sub-parts of a question are to be attempted together in the answer book.

Any page or portion of the page left blank in the Answer Book must be clearly struck out.

Useful Constants

Electron charge (e)	=	$1{\cdot}602 \times 10^{-19}$ C
Electron rest mass (m_e)	=	$9{\cdot}109 \times 10^{-31}$ kg
Proton mass (m_p)	=	$1{\cdot}672 \times 10^{-27}$ kg
Vacuum permittivity (ε_0)	=	$8{\cdot}854 \times 10^{-12}$ farad/m
Vacuum permeability (μ_0)	=	$1{\cdot}257 \times 10^{-6}$ henry/m
Velocity of light in free space (c)	=	3×10^8m/s
Boltzmann constant (k)	=	$1{\cdot}38 \times 10^{-23}$ J/K
Electron volt (eV)	=	$1{\cdot}602 \times 10^{-19}$ J
Planck's constant (h)	=	$6{\cdot}62 \times 10^{-34}$ J-s
Stefan's constant (σ)	=	$5{\cdot}67 \times 10^{-8}$ W m^{-2} K^{-4}
Avogadro's number (N)	=	$6{\cdot}02 \times 10^{26}$ $kmol^{-1}$
Gas constant (R)	=	$8{\cdot}31 \times 10^3$ J $kmol^{-1}$ K^{-1}
exp (1)	=	2·7183

SECTION A

Q.1. Answer all of the following : *8×5=40*

(a) A block of mass m is attached to one end of a combination of two massless springs connected in series. The other end of the combination is fixed to a rigid support. The spring constants of the two springs are k_1 and k_2, respectively. The block is free to move on a frictionless horizontal surface. If the block is pulled a little and then released, calculate the frequency of oscillation of the block. *8*

(b) Obtain an expression for the angular speed of the Earth at which Coriolis force makes objects fly from its surface. *8*

(c) Consider a zone plate with radii $r_n = 0{\cdot}11\sqrt{n}$ cm illuminated by a monochromatic light of wavelength 589 nm. Calculate the positions of first two foci. *8*

(d) A satellite revolves in a circular orbit around the Earth at a certain height above it. Calculate the time period of revolution of the satellite, if the radius of the Earth is significantly higher than the height at which the satellite revolves. *8*

(e) A plano-convex lens of radius 1·0 m is placed on an optically flat glass plate. The space between the lens and the glass plate is filled with a liquid. The diameter of the 5^{th} ring changes to $3{\cdot}0 \times 10^{-3}$ m. Calculate the refractive index of the liquid when the ring is bright. The wavelength of light used is 589 nm. *8*

Q.2 (a) Write down the equation of motion of a weakly damped harmonic oscillator driven by a harmonic force. Obtain an expression for the maximum amplitude of oscillation under steady-state conditions. *20*

(b) An oscillator of mass 0·01 kg draws maximum power at a frequency of 96 Hz with half power points at 93 Hz and 99 Hz. If the amplitude of driving force is 3·88 N, calculate (i) quality factor, (ii) the damping factors and amplitude of the oscillator at resonance. *20*

Q.3 (a) In a double slit interference experiment, show that the fringe shape is a hyperbola. *20*

(b) If a thin sheet of glass of thickness t and refractive index μ is placed in the path of one of the interfering waves, show that the distance through which a fringe is displaced is a function of t. *10*

(c) Discuss spatial evolution of Fresnel diffraction into Fraunhofer diffraction. *10*

Q.4. (a) Explain the lasing action of He – Ne laser using energy level diagram and describe the operation of He – Ne laser experimental set-up. *20*

(b) Discuss the applications of lasers in communication and medicine. *10*

(c) Classify fibers based on the number of modes that can propagate through them. Depict step-index and graded-index multimode fibers pictorially. *10*

SECTION B

Q.5. Answer all of the following : *8×5=40*

(a) Using Poisson equation and spherical co-ordinates, calculate the density of continuous charge distribution that will provide the Yukawa potential $\phi = \frac{\exp(-\alpha r)}{r}$, where α is a constant. *8*

(b) Sea water has resistivity 0·3 Ωm and its dielectric constant is 81. Calculate the ratio of the amplitudes of the conduction and polarisation current intensities when the applied field is oscillating at 100 MHz. *8*

(c) A plane electromagnetic wave is given by

$$E_z = a \cos \omega x \cos \omega t$$

and $H_y = -a \sin \omega x \sin \omega t$.

Evaluate the instantaneous value of the Poynting vector $\vec{S}$ and show that $< \vec{S} > = 0$. *8*

(d) Show that Wien's law and Stefan–Boltzmann law are limiting cases of Planck's radiation law. *8*

(e) Calculate the net change in entropy when 10 g water at 60°C is mixed with 30 g water at 20°C. *8*

Q.6 (a) What do you understand by the term polarization in dielectrics ? Obtain Clausius–Mossotti formula for linear dielectrics. *20*

(b) When the current in an R – L circuit is decaying, what fraction of the original energy stored in the inductor has been dissipated after 2·3 time constant ? *10*

(c) With reference to ferromagnetic materials, explain the terms hysteresis and hysteresis loops. *10*

Q.7 (a) What is transport phenomenon ? Obtain the expression for the coefficient of viscosity. Discuss its temperature dependence. *20*

(b) Define a black body. How can we realise a black body in practice ? Derive expression for Planck's radiation law. *15*

(c) For a completely degenerate BE gas, discuss the condition for onset of BE condensation. *5*

Q.8. (a) Establish Van der Waals equation of state for a real gas. Deduce expressions for critical constants and show that critical coefficient is independent of the nature of gas. *20*

(b) Discuss the significance of Saha's ionisation formula in classification of stars. *10*

(c) State Dulong–Petit's law and discuss its limitations in explaining heat capacities of solids. How were these efficiencies overcome by Debye ? *10*