# 2015

( October )

## PHYSICS

( Elective/Honours )

FIRST PAPER

**( Mechanics, Optics, Acoustics )**

*Marks* : 75

*Time* : 3 hours

*The figures in the margin indicate full marks for the questions*

Answer Question No. **1** which is compulsory and *any* **four** from the rest

*( Results of Question No. 1 should be in SI units )*

**1.** *(a)* A solid sphere of radius 0·3 m is made of a material of density $\rho = 5000 \text{ kg/m}^3$. Find the moment of inertia about an axis through the centre of the sphere. 5

(b) A zone plate is designed to bring a parallel beam of light of wavelength 600 nm to the first focus at a distance of 2 m. Calculate the radius of the central element of the zone plate. 5

(c) An electron at rest has a mass of $9{\cdot}11\times10^{-31}$ kg. At what speed would the mass of the electron be doubled? 5

2. (a) A reference frame $S'$ rotates with respect to an inertial frame $S$ with a uniform angular velocity $\vec{\omega}$. If the position, velocity and acceleration of a particle in frame $S'$ are represented by $\vec{r}$, $\vec{v}'$ and $\vec{a}'$ respectively, then show that the acceleration of the particle in frame $S$ is given by

$$\vec{a} = \vec{a}' + 2\vec{\omega}\times\vec{v}' + \vec{\omega}\times(\vec{\omega}\times\vec{r})$$ 7

(b) What is conservative force? Give two examples of conservative force. Show that a central force is conservative. 1+1+3=5

(c) Deduce an expression for the gravitational field at a point on the outer surface of a shell of radius $R$. 3





3. (a) Define 'centre of mass' of a system. Show that when there is no external force acting on a body, the acceleration of the centre of mass is zero and its velocity is constant. 1+3=4

(b) In a one-dimensional elastic collision of two particles of equal mass, show that the particles simply interchange their velocities after collision. 3

(c) Describe the Michelson-Morley experiment and discuss its significance. 6+2=8

4. (a) State Hooke's law and deduce the relation between the elastic constants, $Y$, $K$, $\eta$ of an isotropic solid (symbols have their usual meanings). 1+6=7

(b) Deduce the equation of continuity of flow of a non-viscous, incompressible fluid. 3

(c) Define 'capillarity' and 'surface tension'. When the size of a soap bubble is increased by blowing more air into it, the surface area increases. Does it mean that the average separation between the surface molecules is increased? Explain. 1+1+3=5

5. *(a)* What is Fermat's principle? Can the optical path length between two points ever be less than the geometrical path length between those points? 1+2=3

*(b)* What is chromatic aberration? Derive the condition of achromatism of a combination of two thin coaxial lenses, when they are *(i)* in contact and *(ii)* separated by a distance. 1+3+3=7

*(c)* With the help of a ray diagram, explain the working of a Ramsden eyepiece. Indicate, in a diagram, the position of the cardinal points in Ramsden's eyepiece. 1+3+1=5

6. *(a)* Why do we see colours when white light falls on a thin film of transparent medium? 2

*(b)* Differentiate between fringes of equal inclination and fringes of equal thickness. 3

*(c)* Give the theory of Newton's rings. How can the wavelength of monochromatic light be measured with the help of Newton's rings? 6+4=10

7. *(a)* What is zone plate? Write a formula for its focal length. Show that a zone plate has multiple foci. 1+1+3=5





*(b)* What is quarter-wave plate? Distinguish between a quarter-wave plate and a half-wave plate. Mention two applications of a quarter-wave plate. 1+2+2=5

*(c)* Explain Fresnel's theory of optical rotation of the plane of polarization. 5

8. *(a)* Distinguish between 'normal' and 'anomalous' dispersions. Give a simple theory of Rayleigh scattering. 2+3=5

*(b)* What are ultrasonic vibrations? Describe a simple method to generate ultrasonic waves. Mention three applications of ultrasonic waves. 1+3+3=7

*(c)* Define 'reverberation time' and 'absorption coefficient' in acoustics. 1½+1½=3

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