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( February )

PHYSICS

( Elective/Honours )

( Mechanics, Optics, Acoustics )

[ PHY-01 (T) ]

Marks : 75

Time : 3 hours

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

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

1. (a) Two solid spheres of masses 100 kg and 1000 kg are at a distance of 10 m apart. Calculate the gravitational potential and field intensity at the middle point of the line joining them.  
( $G = 6.67 \times 10^{-11} \text{ Nm}^2\text{kg}^{-2}$ ) 5
- (b) A flywheel in the form of a circular disc has a radius 40 cm and mass 1 kg. Calculate the work which must be done on the flywheel to increase its speed of rotation from 10 to 20 revolutions per second. 5

- (c) Two thin converging lenses of 0.2 m (1st lens) and 0.3 m (2nd lens) focal lengths are placed co-axially 0.1 m apart in air. An object is located 0.6 m in front of the 1st lens. Find the position of the two principal planes and that of the final image from the second lens.  $1\frac{1}{2}+1\frac{1}{2}+2=5$

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  $\vec{a}' = \vec{a} - 2\vec{\omega} \times \vec{v} - \vec{\omega} \times (\vec{\omega} \times \vec{r})$ . 6
- (b) Define 'centre of mass' of a system. Show that in the absence of an external force acting on a body, the acceleration of the centre of mass is zero and its velocity is constant.  $1\frac{1}{2}+3\frac{1}{2}=5$
- (c) What is central force? Show that for a particle moving under the action of a central force, its aerial velocity remains constant.  $1+3=4$
3. (a) Show that there is a loss of kinetic energy due to direct impact of inelastic collision of two rigid bodies. 3

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- (b) Describe the Michelson-Morley experiment and discuss its significance. 6+2=8
- (c) Derive Einstein's mass-energy relation. 4
4. (a) State parallel axes theorem for a lamina and hence use the theorem to find moment of inertia of a solid sphere about one of its tangent. 2+3=5
- (b) What is a cantilever? If  $l$  is the length of a cantilever which is rigidly clamped at one end and on the other end, a load  $W$  is applied, show that the deflection ( $y$ ) due to the load applied to the free end of the cantilever is equal to  $y = \frac{Wl^3}{3YI}$ , where the symbols have their usual meanings. 1+4=5
- (c) State and prove Bernoulli's theorem. 1+4=5
5. (a) State and explain Fermat's principle. Using this principle, prove the laws of refraction for a plane boundary separating two media. 2+4=6
- (b) What are aplanatic points? Derive the aplanatic points of a sphere. 1+3=4

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- (c) Obtain the system matrix of a thick lens and hence derive the thin lens formula. 5
6. (a) What are Newton's rings? Describe the construction and formation of Newton's rings. How is the wavelength of sodium light determined by Newton's rings method? 1+4+3=8
- (b) Explain the construction of Fresnel's half period zones. Show that the area of each zone of a plane wavefront is equal to  $b$ , where  $b$  is the distance of the external point on the screen from the wavefront. Show that the total amplitude at an external point mainly come from the first half period zone. 3+2+2=7
7. (a) Give the construction, principle of action and production of fringes of Fabry-Perot interferometer. 2+3+2=7
- (b) Discuss the electromagnetic theory of double refraction in uniaxial crystals. 3
- (c) What is quarter-wave plate? Distinguish between a quarter-wave plate and a half-wave plate. Calculate the thickness of a half-wave plate for light of

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wavelength  $6000 \text{ \AA}$ . The refractive index of the material of the plate for the ordinary ray is 1.544 and that for extra-ordinary ray is 1.553.  $1+2+2=5$

8. (a) Distinguish between 'normal' and 'anomalous' dispersions. Briefly explain Rayleigh scattering.  $2+3=5$
- (b) What is meant by ultrasonics? Describe one method of production of ultrasonic waves.  $1+3=4$
- (c) What is reverberation time? Derive Sabine's formula for reverberation time.  $1+5=6$

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