## 2022

( 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.

$$
\left(G=6.67 \times 10^{-11} \mathrm{Nm}^{2} \mathrm{~kg}^{-2}\right)
$$

(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.
(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 1 st lens. Find the position of the two principal planes and that of the final image from the second lens. $11 / 2+11 / 2+2=5$
2. (a) A reference frame $S^{\prime}$ 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 $S^{\prime}$ are represented by $\vec{r}, \vec{v}^{\prime}$ and $\vec{a}^{\prime}$ respectively, then show that the acceleration of the particle in frame $S$ is given by $\vec{a}=\vec{a}^{\prime}+2 \vec{\omega} \times \vec{v}^{\prime}+\vec{\omega} \times(\vec{\omega} \times \vec{r})$.
(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. $1 \frac{112}{2}+31 / 2=5$
(c) What is central force? Show that for a particle moving under the action of a central force, its aerial velocity remains constant.
3. (a) Show that there is a loss of kinetic energy due to direct impact of inelastic collision of two rigid bodies.
(b) Describe the Michelson-Morley experiment and discuss its significance.
(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 $y=\frac{W l^{3}}{3 Y I}$, 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. $1+3=4$
(c) Obtain the system matrix of a thick lens and hence derive the thin lens formula.
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 $\pi b \lambda$, 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.
(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

## ( 5 )

wavelength $6000 \AA$. The refractive index of the material of the plate for the ordinary ray is 1.544 and that for extra-ordinary ray is $1.553 . \quad 1+2+2=5$
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.
$1+5=6$

