KATHMANDU UNIVERSITY
End Semester Examination
March 2025

Marks Scored:

Level : B.Sc./B.Tech.
Year : I
05 March 2025
Course : PHYS 104
Semester : I
Exam Roll No. :
Time: 30 mins.
F. M. : 20
Registration No.:
Date :

SECTION "A"
[20Q. × 1 = 20 marks]

Choose and encircle the most appropriate answer.

1. A force $\vec{F} = (5\hat{i} + 3\hat{j} + 2\hat{k})$ N is applied over a particle which displaces it from its origin to the point $\vec{r} = (2\hat{i} - \hat{j})$ m. The work done on the particle is
   a. −7 J b. 7 J c. 11 J d. 13 J

2. The potential energy associated with the force between two neutral atoms in a diatomic molecule can be modeled by the Lennard–Jones potential energy function, $U(x) = \frac{a}{x^{12}} - \frac{b}{x^6}$, where a and b are positive constants and x is the separation of the atoms. The force between two atoms is
   a. $F_x = \frac{-12a}{x^{12}} - \frac{6b}{x^7}$ b. $F_x = \frac{-12b}{x^{12}} + \frac{6a}{x^7}$ c. $F_x = \frac{12a}{x^{13}} - \frac{6b}{x^7}$ d. $F_x = \frac{12a}{x^{15}} - \frac{6b}{x^7}$

3. The minimum time period of compound pendulum is
   a. $T_{\min} = \sqrt{2\pi \frac{2k}{g}}$ b. $T_{\min} = \pi\sqrt{\frac{2k}{g}}$ c. $T_{\min} = 2\pi\sqrt{\frac{k}{g}}$ d. $T_{\min} = \pi\sqrt{\frac{8k}{g}}$

4. A particle of mass m moving with a velocity v makes head on elastic collision with another article of same mass and initially at rest. The velocity of the first particle after the collision is
   a. 0 b. v c. $-v$ d. $2v$

5. A particle moves such that its acceleration a is given by $a = -b\,x$, where x is displacement from equilibrium position and b is a constant. The period of oscillation is
   a. $\frac{2\pi}{\sqrt{b}}$ b. $2\pi\sqrt{b}$ c. $\frac{2\pi}{\sqrt{a}}$ d. $\frac{2\pi}{b}$

6. Water flows through a horizontal pipe with varying cross-sectional areas. At point A, the cross-sectional area is 0.05 m^2 and the water velocity is 4 m/s. The velocity of the water at point B, where the cross-sectional area 0.02 m^2 is
   a. 4 m/s b. 6 m/s c. 8 m/s d. 10 m/s

7. Three particles are placed in the xy – plane. A 30 gm particle is located at (3,4) m and 40 gm particle are located at (-2, -2) m. Where a 20 gm particle must be placed so that the centre of mass of the three-particle system is at the origin?

a. (0.5, 2) m b. (1, 1.5) m c. (–0.5, – 2) m d. (1.5, 1) m

8. When the material is made excited by heating or otherwise, it emits light of specific wavelength and on the screen, we get some colored lines. This spectrum is known as

a. Absorption spectrum b. Emission line spectrum

c. Continuous Spectrum d. Band Spectrum

9. In a Carnot cycle, the temperature of the working substance at the end of the cycle is

a. Less than that at the beginning b. More than that at the beginning

c. Equal to that at the beginning d. Zero

10. The specific heat of gas

a. has only two values 0 and 1 b. has a unique value at given temperature

c. can have any value between 0 and ∞ d. depends upon the mass of the gas

11. Which series of hydrogen atom lies in visible region?

a. Lyman series b. Balmer series c. Bracket series d. Paschen series

12. The expression for the maximum number of orders in a grating spectrum is given by

a. $\frac{\lambda}{a+b}$ b. $\frac{a}{\lambda}$ c. $\frac{b}{\lambda}$ d. $\frac{a+b}{2\lambda}$

13. If λ_m is the wavelength corresponding to maximum energy and T is the absolute temperature then according to Wein's displacement law which of the following expression is true?

a. $\lambda_m - T = \text{constant}$ b. $\lambda_m + T = \text{constant}$

c. $\frac{\lambda_m}{T} = \text{constant}$ d. $\lambda_m T = \text{constant}$

14. The relationship between decay constant λ and half-life $T_{1/2}$ of the radioactive substance is

a. $T_{1/2} = \frac{0.693}{\lambda}$ b. $T_{1/2} = \frac{0.793}{\lambda}$ c. $T_{1/2} = \frac{0.893}{\lambda}$ d. $T_{1/2} = \frac{0.993}{\lambda}$

15. In elliptical polarization, the electric field of light consists of two linear components perpendicular to each other, unequal in amplitude but have a phase difference of

a. π b. $\pi / 2$ c. $\pi / 4$ d. 2π

Fill in the blanks with most appropriate answer:

16. The phenomenon of ejecting magnetic flux from the specimen placed in magnetic field by cooling through transition temperature for superconductivity is called the_____.

17. The differential equation of damped harmonic oscillation is _____.

18. In Young's double slit experiment, the distance between the slits is reduced to half and the distance between the slit and screen is doubled, then the fringe width increases by _____.

19. The process in which heat is transmitted from one place to the other by the actual movement of the heated particles is called _____.

20. When ray of light is passed through some crystals, it splits up into two refracted rays. This phenomenon is called _____.

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F. M. : 55

SECTION "B"
[5Q × 4 = 20 marks]

Attempt ALL questions.

1. Define centre of mass. Locate the centre of mass of a homogenous semicircular disc of radius R and total mass M.

2. Compute the thickness of half wave plate and quarter wave plate for sodium light, given, $\mu_o = 1.54$ and the ratio of velocity of O-component and E-component is 1.007. Is the crystal positive or negative?

OR

Calculate the increase in entropy when 20 gm of water at 20°C is converted in to vapour at 100°C. (Given: Specific heat of water is 4.2 $Jgm^{-1}\,°C^{-1}$ and latent heat of water is 2.27×10^3 Jgm^{-1}.)

3. What is perfectly inelastic collision? Show that in a sticking collision, the kinetic energy after collision is less than the kinetic energy before collision.

4. Show that the thermal conductivity of the material of the uniform rod of length l and mass m is given by $K = \dfrac{msl}{\pi r^2(\theta_1 - \theta_2)}\dfrac{d\theta}{dt}$, where the symbols have their usual significance.

OR

Formulate the second law of thermodynamics in terms of entropy. Prove that $\int P\,dV = \int T\,dS$, the symbol having their usual significance.

5. What is diffraction? Find the resultant amplitude of n waves.

OR

With well labeled diagram describe the working principle of GM counter.

SECTION "C"
[5Q × 7 = 35 Marks]

6. Establish the differential equation of mass loaded horizontal spring and solve it. Obtain its time period and frequency. Show that total energy $E = K_{max} = U_{max} = \dfrac{1}{2}kA^2$.

P.T.O.

7. Explain the difference between conservative and non-conservative forces with examples. Show that total mechanical energy remains conserved when a conservative force acts on a system, and also show that total energy remains conserved when all forces act on the system.

OR

State and prove parallel axis theorem. Determine the rotational inertia of a uniform slender rod of length L about an axis through its center of mass and its one end.

8. How Newton's rings are formed? Derive an expression to find the diameter of n^{th} dark and bright fringes from center of newton's ring. Hence show that the rings are not equally spaced.

OR

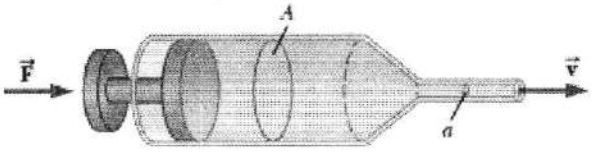
Derive the adiabatic equation for a perfect gas (PV^{γ} = constant). Also, express it in terms of temperature and volume as well as temperature and pressure.

9. Explain the quantum theory of the Raman effect. Describe the formation of Stokes and anti-Stokes lines using an energy-level diagram. What are the key characteristics of the Raman effect?

OR

Describe the working principle and operational procedure of Nuclear Magnetic Resonance (NMR) with a schematic diagram.

10. A hypodermic syringe contains a medicine with the density of water as shown in figure below. The barrel of the syringe has a cross-sectional area $A = 2.5 \times 10^{-5}\ m^2$, and the needle has a cross-sectional area $a = 1 \times 10^{-8}\ m^2$. In the absence of a force on the plunger, the pressure everywhere is 1 atm. A force $\vec{F}$ of magnitude 2 N acts on the plunger, making medicine squirt horizontally from the needle. Determine the speed of the medicine as it leaves the needle's tip.



OR

A plane transmission grating has 6000 lines/cm. It is used to obtain a spectrum of light from sodium lamp in second order. Calculate the angular separation between two sodium lines 5890 Å and 5896 Å.