KATHMANDU UNIVERSITY
End Semester Examination
June/July, 2023

Marks Scored:

Level : B.E./B.Sc./B.Tech.
Year : I

Course : PHYS 101
Semester : I

Exam. Roll No. :

Time: 30 mins.

F.M. : 15

Registration No.:

Date : 03 JUL 2023

SECTION "A"
[15Q. × 1 = 15 marks]

**Encircle the most appropriate alternative from each set of choices.** The symbols, unless mentioned otherwise, have their usual meanings.

1. Aaryan and David are loading identical cement blocks onto David's pickup truck. Aaryan lifts his block straight up from the ground to the truck, whereas David slides his block up a ramp containing frictionless rollers. Which statement is true about the work done on the block–Earth system?
   a. Aaryan does more work than David.
   b. Aaryan and David do the same amount of work.
   c. David does more work than Aaryan.
   d. None of those statements is necessarily true because the angle of the incline is unknown.

2. If two particles have equal kinetic energies, are their momenta equal?
   a. yes, always
   b. no, never
   c. yes, if both their masses and directions of motion are the same
   d. yes, as long as they move along parallel lines

3. The reduced mass of hydrogen atom is nearly equal to
   a. mass of electron.
   b. product of masses of proton and electron.
   c. mass of proton.
   d. ratio of masses of proton and electron.

4. The uniform sphere of radius R and mass M rotates freely about a horizontal axis that is tangent to an equatorial plane of the sphere, as shown in Figure A-1. The radius of gyration of the sphere about this axis is

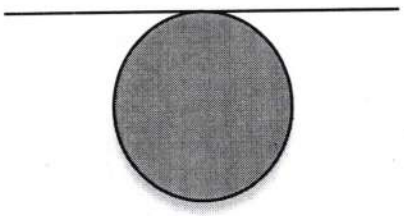

Figure A-1

   a. $\left(\sqrt{\frac{2}{5}}\right)R$  b. $\left(\sqrt{\frac{5}{4}}\right)R$  c. $\left(\sqrt{\frac{7}{2}}\right)R$  d. $\left(\sqrt{\frac{7}{5}}\right)R$

5. A block–spring system vibrating on a frictionless, horizontal surface with an amplitude of 6.0 cm has an energy of 12 J. If the block is replaced by one whose mass is twice the mass of the original block and the amplitude of the motion is again 6.0 cm, what is the energy of the system?
   a. 6 J  b. 12 J  c. 24 J  d. 48 J

6. As an object moves from point A to point B only two forces act on it: one force is nonconservative and does –30 J of work, the other force is conservative and does +50 J of work. Between A and B,
   a. the kinetic energy of object increases, mechanical energy decreases.
   b. the kinetic energy of object decreases, mechanical energy decreases.
   c. the kinetic energy of object decreases, mechanical energy increases.
   d. the kinetic energy of object increases, mechanical energy increases.

7. Bernoulli's theorem is a consequence of
   a. conservation of mass.
   b. conservation of energy.
   c. conservation of linear momentum.
   d. conservation of angular momentum.

8. Suppose Young's double-slit experiment is performed in air using red light and then the apparatus is immersed in water. What happens to the interference pattern on the screen?
   a. It disappears.
   b. The bright and dark fringes stay in the same locations, but the contrast is reduced.
   c. The bright fringes are closer together.
   d. No change happens in the interference pattern.

9. If plane polarized light is sent through two polarizers, the first at 45° to the original plane of polarization and the second at 90° to the original plane of polarization, what fraction of the original polarized intensity passes through the last polarizer?
   a. 0
   b. $\frac{1}{2}$
   c. $\frac{1}{4}$
   d. $\frac{1}{8}$

10. The SI unit of thermal conductivity of the material is
   a. joule meter kelvin.
   b. joule per meter kelvin.
   c. watt meter kelvin.
   d. watt per meter kelvin.

***Fill the following blanks with appropriate answers.***

11. The ballistic pendulum is an apparatus used to measure the speed of a fast-moving projectile such as a bullet. A projectile of mass 9.5 g is fired into a large block of wood of mass 5.4 kg suspended from some light wires. If the projectile embeds in the block, and the entire system swings through a height 6.3 cm, then the speed of the projectile is .....

12. When the damping is small, the forced oscillations reach their maximum displacement (amplitude) when the driving frequency is equal to the natural frequency. This condition is known as .....

13. Assume Young's modulus for bone is $1.50\times10^{10}$ N/m$^2$. The bone breaks if stress greater than $1.50 \times 10^8$ N/m$^2$ is imposed on it. The maximum force that can be exerted on the femur bone in the leg if it has a minimum effective diameter of 2.50 cm is .....

14. Monochromatic light from a He-Ne laser ($\lambda = 632.8$ nm) is incident on a diffraction grating containing 5000 lines/cm. The angle of the first-order maximum is .....

15. Laser operation requires a nonequilibrium condition in which more atoms are in a higher-energy state than in a lower-energy state. Such a condition is called .....

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Semester : I
F. M. : 40

## SECTION "B"
[5Q. × 3 = 15 marks]

1. Derive an expression for the elastic energy stored per unit volume of a wire.

2. What are the differences between elastic and inelastic collisions? A particle of mass $m_1$, moving with a velocity $v_{1i}$, collides head-on with a particle of mass $m_2$ moving with a velocity $v_{2i}$, such that, after collision, they travel with velocities $v_{1f}$ and $v_{2f}$ respectively. If the collision is an elastic one, show that $v_{1i} - v_{2i} = v_{2f} - v_{1f}$.

**OR**

Show that the center of mass of a homogeneous semicircular plate of radius R, placed on upper half of XY-plane with center at origin, is $\left(0, \frac{4R}{3\pi}\right)$.

3. Derive the relation $v_f = v_i + v_{rel} \log_e \left[\frac{M_i}{M_f}\right]$ for rocket, where symbols have their usual meaning.

4. In Young's double-slit experiment, the slits are separated by 0.28 mm, and the screen is placed 4 m away. The distance between the central bright fringe and the fourth bright fringe is 1.2 cm. Determine the frequency of light used in the experiment.

**OR**

Write short notes on: (i) Spontaneous emission, and (ii) Stimulated emission.

5. Write down a theoretical expression for the wavelength distribution developed by Max Planck that agrees very well with the experimental curves. Deduce Wein's displacement law from Planck's radiation formula.

**OR**

The radiation emitted by a star A is 10,000 times that of the sun. If the surface temperature of the sun and the star A is 6000 K and 2000 K respectively, then calculate the ratio of the radii of the star A and the sun.

## SECTION "C"
[5Q × 5 = 25 marks]

6. What do you mean by damped harmonic oscillation? Deduce the differential equation of motion for a damped harmonic oscillator and obtain an expression for displacement. Discuss in detail the case of underdamping.

**OR**

A physical pendulum in the form of a planar object moves in a vertical plane about a horizontal axis with a period $T$. The physical pendulum has mass $m$, and the pivot is located at a distance $d$ from the center of mass. Show that its period is $T = 2\pi\sqrt{\frac{I_{CM} + md^2}{mgd}}$ and has a minimum value when $d$ satisfies $md^2 = I_{CM}$, where $I_{CM}$ is the moment of inertia about an axis passing through its centre of mass and parallel to the axis passing through its pivot point.

7. State the theorem of parallel axes for the moment of inertia. Calculate the moment of inertia of a uniform thin rod of length $L$ and mass $M$ (Figure C-1) (i) about an axis perpendicular to the rod (the $y$ axis) and passing through its center of mass, and (ii) about an axis perpendicular to the rod (the $y'$ axis) and passing through its one end of the rod.

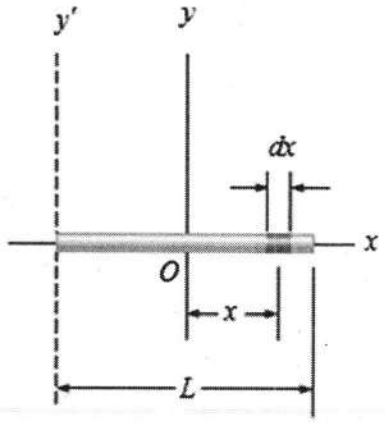


Figure C-1

8. Show that the intensity distribution for the diffraction in a single slit of width $a$ is given by

$$I = I_{max}\left[\frac{\sin(\pi a \sin\theta/\lambda)}{\pi a \sin\theta/\lambda}\right]^2$$

where $I_{max}$ is the intensity at $\theta = 0$ (the central maximum) and $\lambda$ is the wavelength of light used to illuminate the slit. Deduce the conditions for maxima and minima and show that the successive maxima decrease rapidly in intensity.

**OR**

Describe and explain the formation of Newton's rings in reflected light. Derive the relations for the diameters of bright and dark rings and show that fringe width goes on decreasing with the increasing number of fringes.

9. What is plane-polarized light? Name any two methods to produce plane-polarized light. Deduce Brewster's law $\tan\theta_P = \frac{\mu_2}{\mu_1}$ by using Snell's law, where $\theta_P$ is the Brewster's angle, $\mu_1$ is the index of refraction of the medium in which the light initially travels and $\mu_2$ is the index of refraction of the reflecting medium.

10. A block of mass m = 3.57 kg is drawn at a constant speed a distance d = 4.06 meters along a horizontal floor by rope exerting a constant force of magnitude F = 7.68 N making an angle $\theta = 15°$ with the horizontal. Compute (a) the total work done on the block, (b) the work done by the rope on the block, (c) the work done by the friction on the block, (d) the coefficient of kinetic friction between the block and floor.

**OR**

A large storage tank, open at the top and filled with water, develops a small hole it its side at a point 16.0 m below the water level. The rate of flow from the leak is $2.50\times10^{-3}\,m^3/min$ Determine (a) the speed at which the water leaves the hole, and (b) the diameter of the hole.