

KATHMANDU UNIVERSITY  
End Semester Examination  
September 2024

Marks Scored:

Level : B.E.

Year : I

Exam Roll No. :

Time: 30 mins.

Course : PHYS 101

Semester : I

F. M. : 15

Registration No.:

Date : 17 SEP 2024

SECTION "A"

[15Q.  $\times$  1 = 15 marks]

*Choose and encircle the most appropriate answer. Symbols have their usual meanings.*

- For a force to be a conservative force, when applied to a single test body
    - it must have the same value at all points in space.
    - it must have the same direction at all points in space.
    - equal work must be done in equal displacements.
    - no work must be done for motion in closed paths.
  - The force acting on a particle varies as shown in Figure A-1. Find the work done by the force on the particle as it moves  $x = 0$  to  $x = 8.00$  m.
    - 12 J
    - 24 J
    - 18 J
    - 30 J
- Figure A-1
- If the net work done by external forces on a particle is zero, which of the following statements about the particle must be true?
    - Its velocity is zero.
    - Its velocity is decreased.
    - Its velocity is increased.
    - Its speed is unchanged.
  - The reduced mass of positronium, a bound system of electron and positron is equal to
    - the mass of electron.
    - double the mass of the electron.
    - half the mass of the electron.
    - the mass of the positron.
  - When the rate of change of mass (called the burn rate) and the exhaust velocity are constant, a rocket ascends with
    - decreasing acceleration.
    - decreasing velocity.
    - constant velocity.
    - increasing acceleration.
  - The radius of gyration of a uniform thin rod of length  $L$  and mass  $M$  about an axis perpendicular to the rod and passing through its center of mass is
    - $\frac{L}{2\sqrt{3}}$
    - $\frac{L}{\sqrt{3}}$
    - $\frac{M}{2\sqrt{3}}$
    - $2\sqrt{3} L$

7. A physical pendulum of mass  $M$  is pivoted about one end and oscillates in a vertical plane (Figure A-1). The period of oscillation if the amplitude of the motion is small is

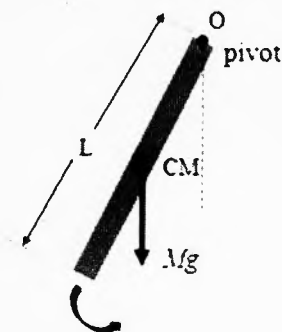


Figure A-1

- a.  $T = 2\pi \sqrt{\frac{L}{g}}$       b.  $T = 2\pi \sqrt{\frac{L}{3g}}$       c.  $T = 2\pi \sqrt{\frac{L}{6g}}$       d.  $T = 2\pi \sqrt{\frac{2L}{3g}}$
8. Two slits separated by 0.10 mm are illuminated with green light ( $\lambda = 540$  nm). Calculate the distance (in cm) from the central bright-region to the fifth bright band if the screen is 1.0 m away.  
 a. 2.3      b. 2.5      c. 2.7      d. 2.1
9. When waves encounter an edge, an obstacle, or an aperture the size of which is comparable to the wavelength of the waves, those waves spread out as they travel and, as a result, undergo interference. This is called \_\_\_\_\_.  
 a. interference      b. diffraction      c. polarization      d. dispersion
10. We can transform unpolarized visible light into polarized light using a polarizing sheet. These sheets, commercially known as \_\_\_\_\_, were invented in 1932 by Edwin Land while he was an undergraduate student at Harvard University.  
 a. Polaroid sheets      b. Optic sheets  
 c. Diffraction gratings      d. Polarization lenses

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

11. A 2.0-kg object moving 5.0 m/s collides with and sticks to an 8.0-kg object initially at rest. The kinetic energy lost by the system as a result of this collision is \_\_\_\_\_
12. Assume Young's modulus for bone is  $1.50 \times 10^{10}$  N/m<sup>2</sup>. The bone breaks if stress greater than  $1.50 \times 10^8$  N/m<sup>2</sup> 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 0.025 m is \_\_\_\_\_
13. According to \_\_\_\_\_ theorem, the sum of the pressure, kinetic energy per unit volume, and gravitational potential energy per unit volume has the same value at all points along a streamline for an ideal fluid.
14. \_\_\_\_\_ is the condition where the number of atoms in the excited state is greater than the number in the ground state, a key requirement for laser operation.
15. Heat energy from the Sun reaches the Earth primarily through the process of \_\_\_\_\_

KATHMANDU UNIVERSITY  
End Semester Examination  
September 2024

Level : B.E.  
Year : I  
Time : 2 hrs. 30 mins.

17 SEP 2024

Course : PHYS 101  
Semester : I  
F. M. : 40

SECTION "B"

[5Q. × 3 = 15 marks]

1. State Hooke's law and show that the elastic potential energy density of a stretched wire is equal to half the product of tensile stress and tensile strain.
2. What are conservative and non-conservative forces in physics, and how do they respectively impact the mechanical energy of a system?

**OR**

Show that the center of mass of a homogeneous semicircular plate of radius 'a' is  $\left(0, \frac{4a}{3\pi}\right)$ .

3. What does LASER stand for? Describe the concept of stimulated emission in laser physics and provide two impactful real-world applications of laser technology.

**OR**

What is Brewster's angle? Derive Brewster's law, using Snell's law.

4. Monochromatic light from a helium-neon laser ( $\lambda = 632.8$  nm) is incident on a diffraction grating containing 6000 grooves per centimeter. Find the angles at which the first- and second-order maxima are observed. What if you looked for the third maximum? Would you find it?

**OR**

Calculate the minimum thickness of a soap-bubble film that results in constructive interference in the reflected light if the film is illuminated with light whose wavelength in free space is  $\lambda = 600$  nm. The index of refraction of the soap film is 1.33. What if the film is twice as thick? Does this situation produce constructive interference?

5. Write down Planck's formula for blackbody radiation that describes the wavelength distribution of emitted light and agrees remarkably well with the experimental curves. Derive Wein's displacement law from Planck's radiation law.

SECTION "C"

[5Q. × 5 = 25 marks]

6. A plano-convex lens with an index of refraction  $\mu$  and a curved side with a radius of curvature R rest on a flat glass surface with the same index of refraction, with air between them.
  - a. Describe an experimental setup, including a diagram, to produce Newton's rings.
  - b. Derive expressions for the radii of the bright and dark Newton's rings observed under these conditions and establish a formula to determine the wavelength of monochromatic light.

**P.T.O.**

7. Explain briefly elastic and inelastic collisions with real-world examples. The ballistic pendulum (Figure B-1) is an apparatus used to measure the speed of a fast-moving projectile such as a bullet. A projectile of mass  $m$  is fired into a large block of wood of mass  $M$  suspended from some light wires. The projectile embeds in the block, and the entire system swings through a height  $h$ . How can we determine the speed of the projectile from a measurement of  $h$ ?

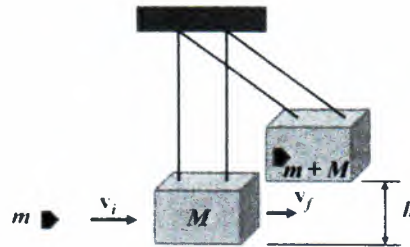


Figure B-1

8. Derive Poiseuille's formula for the volume flow rate of a Newtonian fluid through a horizontal tube with uniform cross-section under steady-state laminar flow conditions.

OR

What is double refraction? Explain the Nicol prism's principle and how it functions as a polarizer and an analyzer.

9. An ideal massless spring can be compressed 1.0 m by a force of 100 N. A block whose mass is  $m = 10$  kg is released from rest at the top of the incline as shown in Figure C-1, the angle of the incline being  $30.0^\circ$ . The block comes to rest momentarily after it has compressed this spring by 2 m. (a) How far has the block moved down the incline at this moment? (b) What is the speed of the block just as it touches the spring?

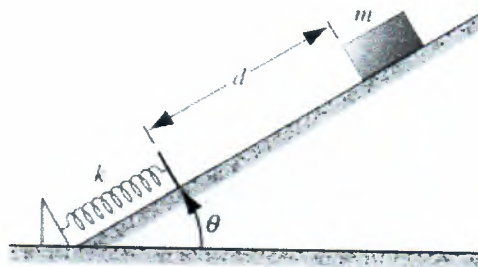


Figure C-1

OR

In an engine, a piston oscillates with simple harmonic motion so that its position varies according to the expression  $x = (5.00 \text{ cm}) \cos\left(2t + \frac{\pi}{6}\right)$ , where  $x$  is in centimeters and  $t$  is in seconds.

- Find the position of the piston at  $t = 0$ .
- Determine the velocity of the piston at  $t = 0$ .
- Calculate the acceleration of the piston at  $t = 0$ .
- Find the period and amplitude of the motion.

10. Derive the differential equation of motion for a forced harmonic oscillator. Solve the equation and determine the condition for maximum amplitude (resonance). Plot an amplitude graph as a function of driving frequency for a forced oscillator with and without damping.

**OR**

State the parallel axis theorem for the moment of inertia. A homogeneous solid sphere has a radius of  $R$  and a mass of  $M$ . Find its moment of inertia (i) about an axis passing through its center and (ii) about a tangent to the sphere.

