PHYSICS ACADEMY OF NORTH EAST
North East India Physics Talent Search 2025

Date of examination: *9 Nov. 2025*
Time: 10:00 AM to 12:00 PM
Maximum marks: 216

Candidate's Roll Number: | | | | | | **Serial No.:**

Code: A

Instructions to candidates

1. Use of smart devices of any kind during the examination is **STRICTLY PROHIBITED**.
2. Use of non-programmable scientific calculator is allowed.
3. In addition to this question booklet, you are provided with an OMR response sheet.
4. On the OMR response sheet, make all the entries carefully in the space provided ONLY in BLOCK CAPITALS as well as by properly darkening the appropriate bubbles. Incomplete/incorrect/carelessly filled information may disqualify your candidature.
5. On the OMR response sheet, use only BLUE or BLACK BALL POINT PEN for making entries and bubbling the answers.
6. In part A, from questions numbered 1 to 48, each question has four alternatives, out of which only one is correct. Choose the correct alternative and fill the appropriate bubble.
7. In part B, from questions numbered 49 to 60, each question has four alternatives, out of which any number of alternatives is correct. Choose **all** the correct alternatives and fill the appropriate bubbles.
8. In part A, each correct answer carries 3 marks whereas 1 mark will be deducted for each wrong answer. In part B, 6 marks will be awarded if all the correct alternatives are marked. There is no negative marking in this part.
9. No candidate should leave the examination hall before the completion of the examination.
10. After submitting OMR response sheet, the candidate may carry with them the question booklet.
11. Please DO NOT make any mark other than filling the appropriate bubbles properly in the space provided on the OMR response sheet.
12. OMR response sheets are generally machine-evaluated, hence CHANGE OF ENTRY IS NOT ALLOWED. Scratching or overwriting may result in a wrong score.
13. Do not write on the back side of the response sheet.

Physical constants you may need

Magnitude of charge on electron	:	$e = 1.6 \times 10^{-19}\,\mathrm{C}$
Mass of electron	:	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
Mass of proton	:	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
Acceleration due to gravity	:	$g = 9.8\,\mathrm{m/s^2}$
Universal gas constant	:	$R = 8.31\,\mathrm{J/mol\,K}$
Boltzmann constant	:	$k = 1.38 \times 10^{-23}\,\mathrm{J/K}$
Atmospheric pressure (at STP)	:	$1\,\mathrm{atm} = 1.01 \times 10^{5}\,\mathrm{Pa}$
Universal gravitational constant	:	$G = 6.67 \times 10^{-11}\,\mathrm{N m^2/kg^2}$
Permeability of free space	:	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H/m}$
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Avogadro's constant	:	$N_A = 6.02 \times 10^{-23}$
Speed of light in free space	:	$c = 3 \times 10^{8}\,\mathrm{m/s}$
Speed of sound in dry air at 0°C	:	$v_0 = 332\,\mathrm{m/s}$
Stefan's constant	:	$\sigma = 5.67 \times 10^{-8}\,\mathrm{W/m^2K^4}$
Planck's constant	:	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
Faraday constant	:	$F = 96\,500\,\mathrm{C/mol}$

PART–A

ONLY ONE out of four options is correct. Bubble the correct option.

1. The escape speed of a projectile on the earth's surface is v_e. A body is projected out with thrice this speed. What is the speed of the body far away from the earth? Ignore the presence of the sun and other planets.

   A. $2v_e$ **B.** $2\sqrt{2}v_e$ C. $\sqrt{2}v_e$ D. $v_e/\sqrt{2}$

2. Four students throw darts at a target. Their results are shown below:

   Case I: All darts are very close to the centre.

   Case II: All darts are clustered together but far from the centre.

   Case III: Darts are scattered all around but their average position is near the centre.

   Case IV: Darts are scattered randomly and far from the centre.

   Which of the following matches the correct interpretation?

   - I = High accuracy, high precision
   - II = Low accuracy, high precision
   - III = High accuracy, low precision
   - IV = Low accuracy, low precision

   Choose the correct option:

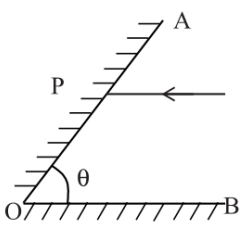
   A. I and II only

   B. I, II, and III only

   C. All of I, II, III, and IV

   D. Only I is correct

3. Two plane mirrors OA and OB are aligned with respect to each other at an angle θ. When a ray of light that is initially parallel to the mirror OB is incident on the mirror OA at the point P, the reflected ray gets reflected again from the mirror OB and finally emerges parallel to the mirror OA. What might be the value of the angle θ?



   A. 30° B. 45° **C.** 60° D. 75°

4. An observer stands on the platform at the front edge of the first bogie of a stationary train. The train starts moving with uniform acceleration and the first bogie takes 5 seconds to cross the observer. If all the bogies of the train are of equal length and the gap between them is negligible, the time taken by the tenth bogie to cross the observer is

   A. 1.07 s B. 0.94 s C. 0.91 s **D. 0.81 s**

5. A conductor of made up of copper has a length l and area of cross section A . It's resistivity is ρ_0 at 25^0C. What would be the percentage increase in it's resistance at 30^0C? (The temperature coefficient of resistivity of copper is $\alpha = 0.004^0\text{C}^{-1}$)

   A. 4% **B.** 2% C. 1% D. 0%

6. Imagine sending information over long distances, not by electric wires but by pulses of light, as fast as possible, with almost no loss. That's what optical fibres do – they are like hair-thin tunnels of glass or plastic that act as such "wires" for light. Which physical principle allows optical fibres to guide light without escaping through their walls?

   A. Interference of light

   B. Diffraction of light

   C. Inelastic scattering of light

   D. Total internal reflection of light

7. A simple pendulum, consisting of a light inextensible string of length attached to a small heavy bob of mass m, is at rest. The bob is imparted a horizontal impulsive force which gives it a velocity of $\sqrt{4gl}$. The speed of the bob at its highest point is

   A. 0 B. $\sqrt{\frac{gl}{3}}$ C. $\sqrt{\frac{2gl}{3}}$ D. $\sqrt{\frac{8gl}{27}}$

8. A resistance of 40Ω is connected to a source of alternating current rated 220 V, 50Hz. The time taken by the current to change from its maximum value to the rms value is

   A. 2.5 S B. 0.25 S **C. 2.5 mS** D. 1.5 mS

9. The refractive index of glass with respect to air is 3/2, while that of water is 4/3. Which of the following statements correctly describes the condition for the critical angle (i_c) at the glass–water interface?

A. $0^0 \leq i_c \leq 30^0$ B. $30^0 \leq i_c \leq 45^0$ C. $45^0 \leq i_c \leq 60^0$ **D.** $45^0 \leq i_c \leq 90^0$

10. The ground state energy of an electron in the hydrogen atom is -13.6 eV. The kinetic energy of an electron in the first excited state ($n = 2$) of the hydrogen atom is

A. +13.6 eV B. -13.6 eV **C. +3.4 eV** D. -3.4 eV

11. In an electrical circuit two resistors of 2Ω and 4Ω respectively are connected in series to a 6 V battery. The heat dissipated by the 4Ω resistor in 5 s will be

A. 5 J B. 10 J **C. 20 J** D. 30 J

12. A beetle flies and lands on a twig 10 cm away from the focus of a thin convex lens on its principal axis. On a wall 40 cm away from the focus on the other side of the lens, a sharp and inverted image of the beetle is formed. What might be the focal length of the lens?

A. 20 cm B. 30 cm C. 40 cm D. 60 cm

13. A mass of 4kg rests on a horizontal plane. The plane is gradually inclined until at an angle $\theta = 30^0$ with the horizontal, the mass just begins to slide. What is the coefficient of static friction between the block and the surface ?

A. $1/2$ B. $1/\sqrt{2}$ C. $1/3$ **D.** $1/\sqrt{3}$

14. Which of the following statements correctly explains why iron (^{56}Fe) is one of the most stable nuclei in nature?

A. Because iron has the highest mass number among naturally occurring elements.

B. Because iron has the maximum number of neutrons per proton in all nuclei.

C. Because iron has the highest binding energy per nucleon, making further fission or fusion energetically unfavorable.

D. Because iron has zero mass defect, so it cannot undergo any nuclear reaction.

15. A baby is sitting on the principal axis of a convex mirror of focal length f, at a distance $2f$ from the pole in front of the mirror. She starts crawling on principal axis towards the mirror. During the course of her motion, the distance between the baby and her image

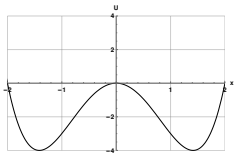
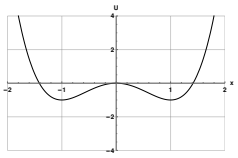
A. Always decreases.

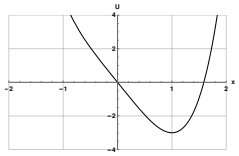
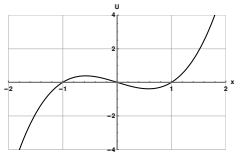
B. Always increases.

C. First decreases, then increases.

D. First increases, then decreases.

16. A particle is under the influence of the one dimensional potential $U = -2x^2 + x^4$. Which of the following plot best describes the potential

A.  **B.** 

C.  D. 

17. The maximum error in the measurement of resistance, current and time for which the current is flowing through the circuit is 1%, 2% and 3% respectively. The maximum percentage error in the measurement of heat dissipated will be A. 2% B. 4% C. 6% **D.** 8%

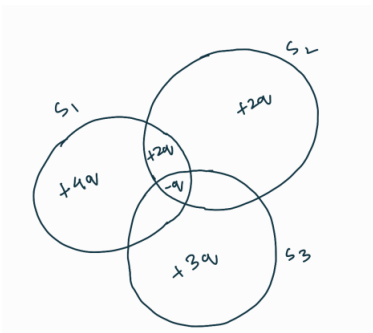
18. A person is prescribed a concave lens of power −0.25 dioptres to correct his myopia for distant vision. What is the maximum distance he could see clearly unaided by the lens?

A. 2 m **B.** 4 m C. 6 m D. 8 m

19. Assuming the earth to be a sphere of uniform mass density, how much would a body weigh half way down to the centre of the earth if it weighed 200 N on the surface?

A. 50 N B. 200 N **C. 100 N** D. 400 N

20. What is the correct ratio of the electric flux passing through the surface S_1, S_2 and S_3 is



A. 4:2:3 **B. 5:3:2** C. 6:3:2 D. 6:4:2

21. Sunlight is scattered by molecules in the atmosphere due to a process called Rayleigh

scattering. If the intensity of scattered light at wavelength 400 nm is I_0, the intensity at wavelength 800 nm, for the same incident flux and same scattering geometry, is approximately

A. $I_0/2$ B. $I_0/4$ C. $I_0/8$ **D.** $I_0/16$

22. On shining a faint red light on a metal surface, nothing happens. In order for photoelectrons to be ejected from the metal surface,

A. The brighness of the red light must be increased.

B. The metal surface must be heated before shining red light.

C. The metal surface must be rubbed with a woolen cloth to increase its number of electrons.

D. Blue light should be used instead of red light.

23. A string of length L is fixed at both ends and set into vibration. A standing wave is formed with three anti-nodes. Which statement is correct about the frequency of this mode?

A. It is the fundamental frequency.

B. It is the second harmonic.

C. It is the first overtone.

D. Its frequency is three times the fundamental frequency.

24. A prism of apex angle $A = 60°$ is made from glass with refractive index $\mu = 1.5$. For a monochromatic ray the prism is used in the condition of minimum deviation. Then the angle of minimum deviation δ_m is approximately [use $\sin^{-1}(0.75) \approx 48.6$]

A. 11.4° B. 35.7° **C.** 37.2° D. 78.6°

25. The moment of inertia of a semicircular disc of mass M and radius R is

A. MR^2 B. $\frac{MR^2}{2}$ C. $\frac{MR^2}{4}$ D. $2MR^2$

26. When an ambulance with its siren on comes towards you and then goes away, what changes in the sound you hear?

A. The sound becomes higher in pitch as it comes closer and lower in pitch as it goes away.

B. The sound travels faster towards you and slower when moving away.

C. The pitch is lowest when the ambulance is right in front of you.

D. Only loudness changes; pitch remains the same.

27. A thin converging lens produces a real image whose size is twice the size of the object. When the object is moved 10 cm closer to the lens, the real image becomes thrice the size of the object. The focal length of the lens is

A. 30 cm B. 40 cm C. 50 cm **D.** 60 cm

28. A marble block of mass 10 kg lying on ice when given a velocity of $5m/s$ is stopped by friction in $10s$. Then the coefficient of friction is (consider $g = 10m/s$)

A. 0.5 B. 0.25 C. 0.005 **D. 0.05**

29. A doctor uses ultrasound to examine internal organs because:

A. Ultrasound travels slower than normal sound.

B. Ultrasound gets completely absorbed by bones.

C. Ultrasound can reflect from boundaries inside the body.

D. Human ears can hear ultrasound clearly.

30. A bi-convex glass lens has refractive index $\mu_g = 1.5$ and focal length 20 cm in air. The same lens is immersed in a liquid of refractive index $\mu_l = 1.2$. Then the focal length of the lens in the liquid becomes

A. 10 cm B. 20 cm **C.** 40 cm D. 80 cm

31. A ball of mass m falls from a height h on a vertical spring of spring constant k whose bottom end is fixed to ground. Neglecting the length of the spring compared to the height h the displacement of the spring from its equilibrium position would be

A. $\sqrt{\frac{mgh}{k}}$ B. $\sqrt{\frac{2mgh}{k}}$ **C.** $\frac{mg}{k}\left(1+\sqrt{1+\frac{2kh}{mg}}\right)$
D. $\frac{mg}{k}\left(1+\sqrt{1+\frac{kh}{mg}}\right)$

32. Why does an LED emit light when forward biased, but a normal silicon diode does not?

A. LEDs allow current only in reverse bias, while silicon diodes allow it in forward bias.

B. In LEDs, electron–hole recombination releases energy in the form of visible light.

C. Silicon diodes absorb light instead of emitting it.

D. LEDs do not have a depletion region like silicon diodes.

33. A spherical container with expandable surface contains an ideal gas at temperature T. If the temperature is increased to $8T$, by what factor radius of the container would change

A. increases 4 times **B. increases 2 times**
C. decreases to 1/4 D. decreases to 1/2

34. A solid cylinder of mass M and radius R rolls without slipping down an inclined plane of angle 30°. The linear acceleration of its centre of mass is a. If the same cylinder slides without friction, its acceleration is a'. What is the ratio a/a'?

A. $\frac{1}{3}$ B. $\frac{1}{4}$ C. $\frac{3}{2}$ **D.** $\frac{2}{3}$

35. How would you determine if an AC circuit is capacitive in nature?

A. I **leads** V B. V leads I C. V and I are in-phase. D. V and I are out-of-phase.

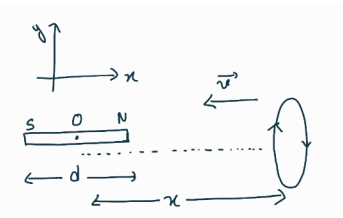
36. Which of the following are considered to be important factors for the origin of life on the Earth?

A. The anomalous behaviour of water.
B. The high specific heat capacity of water.
C. The polarity of the water molecule.
D. All of the above.

37. A ring, a disk a solid sphere and a solid cylinder, all of the same mass M are made to race down an inclined surface. Which one of them would lose the race?

A. Ring. B. Disk. C. Sphere. D. Cylinder.

38. The magnetic field due to a magnetic dipole lying in the x axis at an axial point at a sufficiently large distance $x >> d$ from its centre can be approximated to be $\vec{B} \simeq \frac{\mu_0}{4\pi}\frac{2\vec{p}}{x^3}\hat{i}$ ($\vec{p}$ is the dipole moment of the magnetic dipole). A circular loop of area of cross section A is moving towards the dipole with a uniform velocity $\vec{v}$. The induced e.m.f. on the circular loop when it is at a distance x is



A. 0 **B.** $-\frac{3BAv}{x}$ C. $-\frac{3BAv}{4x}$
D. $-\frac{3BAv}{2x}$

39. Two thin lenses L_1 and L_2 (both thin and coaxial) are separated by 30 cm. L_1 and L_2 have focal lengths of +20 cm and +30 cm respectively. An object is placed 40 cm in front of L_1. The final image is formed at a distance from L_2 approximately equal to

A. −7.5 cm B. −4.0 cm **C.** +7.5 cm
D. +4.0 cm

40. A block of mass 2kg is attached to a light spring of force constant 200N/m and placed on a smooth horizontal surface. The block is pulled to stretch the spring by 5cm and released from rest. What is the maximum speed of the block during its motion?

A. 0.25 m/S B. 0.35 m/S **C. 0.50 m/S**
D. 1 m/S

41. A capacitor of capacitance C is connected to a battery of potential difference V. The energy stored in it is E. If another capacitor of capacitance $2C$ is connected in series with the first capacitor (while both remain connected to the same battery), what will be the total energy stored in the combination?

A. $3E$ **B.** $\frac{2}{3}E$ C. $\frac{3}{2}E$ D. $\frac{1}{3}E$

42. According to the first law of thermodynamics, during a phase change, such as melting or boiling, the supplied heat is utilized in

A. Increasing the temperature of the substance
B. Increasing only kinetic energy, not the potential energy
C. Increasing only the internal potential energy, not the kinetic energy
D. The heat supplied is completely lost to the surroundings

43. A cylindrical block of wood of mass M, length L and radius R is floating in water of density ρ. If it is depressed a little, the block undergoes simple harmonic motion. Ignore viscosity. Acceleration due to gravity is g. The angular frequency of oscillation is

A. $\sqrt{\frac{\pi R^2 \rho g}{M}}$ B. $\sqrt{\frac{g}{L}}$ C. $\sqrt{\frac{\pi R^3 \rho g}{ML}}$
D. $\sqrt{\frac{L^2 \rho g}{M}}$

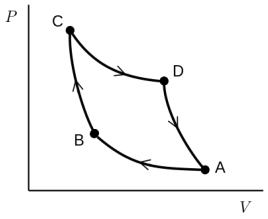
44. Two point charges are placed within an oil whose dielectric constant is κ. The Coulomb force between them will

A. Increase by κ. **B. Decrease by κ.**
C. Increase by κ^2. D. Decrease by κ^2.

45. When heat Q is supplied to a gas, part of it increases its internal energy and part does external work. This statement mathematically defines:

A. Clausius theorem B. Kelvin–Planck statement **C. First law of thermodynamics** D. Second law of thermodynamics

46. In the Carnot cycle shown below, it is given that $P_A = 2$ atm, $P_B = 6$ atm and $P_C = 24$ atm. If $V_A = 1$ L and the adiabatic index of the gas is $\gamma = 2$, then what is the value of V_C?



A. 1/2 L B. 1/3 L **C.** 1/6 L D. 1/12 L

47. The ratio of the kinetic energy required to be given to the satellite to escape Earth's gravitational field to the Kinetic energy required to be given so that the satellite moves in a circular orbit just above earth atmosphere is

A. 1:2 B. 1:3 C. 3:1 **D. 2:1**

48. At a particular instant of time, a charged particle, within a region of crossed E and B fields, is observed to move perpendicular to the plane containing both fields and with a speed that is exactly equal to $v = E/B$. The shape of the particles path is

A. Linear B. Circular C. Helical D. Cycloidal

PART–B

MORE THAN ONE options may be correct. Marks will be awarded only if all of the correct options are bubbled.

49. Two small stars of masses M_1 and M_2 initially far apart are at rest. The stars move towards each other under gravitational attraction. The velocity of approach, when the two stars are a distance d apart, is equal to

A. $\sqrt{\frac{GM_1}{d}} + \sqrt{\frac{GM_2}{d}}$ **B.** $\sqrt{\frac{G(M_1+M_2)}{d}}$
C. $\sqrt{\frac{2GM_1}{d}} + \sqrt{\frac{2GM_2}{d}}$ D. $\sqrt{\frac{2G}{\left(\frac{1}{M_1}+\frac{1}{M_2}\right)d}}$

50. A long straight wire carrying a steady current I lies along the z-axis. A square loop of side a, carrying a current I', lies in the xy-plane such that its nearest side is at a distance r from the wire ($a << r$).

Consider only the magnetic interaction between the wire and the loop.

Which of the following statements are correct?

A. The magnitude of the magnetic force on the nearer side of the loop is greater than that on the farther side..

B. If the currents I and I' flow in the same sense (as seen from $+z$), the net force on the loop is towards the wire (i.e. attractive).

C. The net torque on the loop about the z-axis (the axis of the straight wire) is zero.

D. The loop experiences a net force perpendicular to the xy-plane (i.e. a net force along z).

51. A transparent right-angled triangular prism ABC, with BC as its hypotenuse, is placed in air. A ray incident on the face AB and travelling parallel to the hypotenuse emerges from the face AC grazing the surface, whereas a ray incident on the face AC and also parallel to the hypotenuse is totally internally reflected at the face AB. The range of values of the refractive index μ of the prism material is

A. $\mu > 2$ B. $\mu < \sqrt{\frac{3}{2}}$ C. $\sqrt{2} < \mu < \sqrt{3}$
D. $\sqrt{\frac{3}{2}} < \mu < \sqrt{2}$

52. A block of mass m is pushed along a rough horizontal surface by a constant horizontal

force F for a distance s. The coefficient of kinetic friction between the block and the surface is μ

Which of the following statements is/are correct?

A. The work done by the frictional force is $-\mu mgs$

B. The change is kinetic energy of the block is $Fs-\mu mgs$

C. If $F = \mu mg$ the blocks move with constant velocity

D. The net work done on the block is zero only if $F = 0$

53. Two wires A and B made of the same material have the same length but different radii r_A and r_B ($r_B = 2r_A$). Both are connected in parallel across a battery of emf E with negligible internal resistance. If the total power dissipated in the combination is P, what fraction of the total power is dissipated in wire A?

A. $\frac{1}{5}P$ B. $\frac{1}{4}P$ C. $\frac{1}{3}P$ D. $\frac{1}{2}P$

54. A thin double convex lens of radii of curvature $R_1 = 20\,\text{cm}$ and $R_2 = 60\,\text{cm}$ is made-up of glass with refractive index $\mu = 1.5$. Let the focal length of the lens be f. Choose the correct option(s)

A. In air, $f = 30\,\text{cm}$.

B. The lens behaves as a concave mirror $f_M = 10\,\text{cm}$ when silvered on the R_2 surface.

C. The lens behaves as a concave lens if beyond R_2 surface is filled with a transparent liquid with $\mu = 5/3$.

D. A beam of rays incident parallel to principal axis never focuses behind the lens.

55. A ball of mass m is falling from the top of a multi story building of height h. Which of the following statements are correct about the motion of the ball? (Neglect the air resistance)

A. v increases linearly with t

B. s vs v graph is parabolic

C. mgh equals total K.E. before hitting the ground

D. K.E. linearly increases with t

56. A battery of emf 12 V and internal resistance 1 Ω is connected in series with a resistor $R_1 = 3\Omega$. Across the terminals of R_1, a parallel branch is connected that contains two resistors $R_2 = 6\Omega$ and $R_3 = 3\Omega$ in series. Find the current supplied by the battery (in amperes).

A. $1.2A$ B. $1.5A$ **C.** $1.6A$ D. $1.8A$

57. A thin symmetric bi-convex glass lens of refractive index μ_l is placed in a surrounding medium of refractive index μ_m. Which of the following statements are necessarily true (for arbitrary curvatures, assuming thin-lens approximation)?

A. If $\mu_l \to \mu_m$, $f \to \infty$

B. If $\mu_m > \mu_l$, it becomes diverging

C. Immersing the lens in a medium with μ decreases $|f|$.

D. If $\mu_e l = 1.5$, $\mu_m = 1.2$, the f increases.

58. An incompressible, non-viscous fluid of density ρ steadily flows through a horizontal pipe from cross-sectional area decreases from A_1 to A_2 ($A_1 > A_2$). The pressure and velocity of the fluid while passing through the area A_1 are P_1 and v_1, respectively. The pressure at the cross-sectional area A_2 is

A. $P_1 + \frac{1}{2}\rho\left(1-\frac{A_2^2}{A_1^2}v_1^2\right)$ **B.** $P_1 + \frac{1}{2}\rho\left(1-\frac{A_1^2}{A_2^2}\right)v_1^2$

C. $P_1 + \frac{1}{2}\rho\left(1-\frac{A_1^2}{A_2^2}v_1^2\right)$ D. $P_1 + \frac{1}{2}\rho\left(1-\frac{A_2^2}{A_1^2}\right)v_1^2$

59. As the temperature increases, the behaviour of electrical resistance differs for conductors and semiconductors. Which of the following statements is/are correct?

A. For a metallic conductor, R increases with T

B. For a semiconductor, R decreases with T

C. In conductors, increase in R with T is due to increased lattice vibrations.

D. The T coefficient of R for a semiconductor is negative.

60. Two thin coaxial lenses L_1 and L_2 are placed in contact. Their focal lengths and powers are f_1, f_2 and P_1, P_2 respectively. If the effective focal length is F, which of the following statements are correct?

A. If f_1 and f_2 are both positive, the effective focal length F equals $f_1 + f_2$.

B. The effective power of the combination is $P = P_1 + P_2$.

C. If $f_1 = -f_2$, the combination is afocal.

D. If both f_1 and f_2 are positive, the effective focal length F is always larger than the larger of f_1 and f_2.

***** $\varepsilon\eta\delta$ *****

PHYSICS ACADEMY OF NORTH EAST
North East India Physics Talent Search 2025

Date of examination: *9 Nov. 2025*
Time: 10:00 AM to 12:00 PM
Maximum marks: 216

Candidate's Roll Number: | | | | | | **Serial No.:**

Code: B

Instructions to candidates

1. Use of smart devices of any kind during the examination is **STRICTLY PROHIBITED**.
2. Use of non-programmable scientific calculator is allowed.
3. In addition to this question booklet, you are provided with an OMR response sheet.
4. On the OMR response sheet, make all the entries carefully in the space provided ONLY in BLOCK CAPITALS as well as by properly darkening the appropriate bubbles. Incomplete/incorrect/carelessly filled information may disqualify your candidature.
5. On the OMR response sheet, use only BLUE or BLACK BALL POINT PEN for making entries and bubbling the answers.
6. In part A, from questions numbered 1 to 48, each question has four alternatives, out of which only one is correct. Choose the correct alternative and fill the appropriate bubble.
7. In part B, from questions numbered 49 to 60, each question has four alternatives, out of which any number of alternatives is correct. Choose **all** the correct alternatives and fill the appropriate bubbles.
8. In part A, each correct answer carries 3 marks whereas 1 mark will be deducted for each wrong answer. In part B, 6 marks will be awarded if all the correct alternatives are marked. There is no negative marking in this part.
9. No candidate should leave the examination hall before the completion of the examination.
10. After submitting OMR response sheet, the candidate may carry with them the question booklet.
11. Please DO NOT make any mark other than filling the appropriate bubbles properly in the space provided on the OMR response sheet.
12. OMR response sheets are generally machine-evaluated, hence CHANGE OF ENTRY IS NOT ALLOWED. Scratching or overwriting may result in a wrong score.
13. Do not write on the back side of the response sheet.

Physical constants you may need

Magnitude of charge on electron	:	$e = 1.6 \times 10^{-19}\,\mathrm{C}$
Mass of electron	:	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
Mass of proton	:	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
Acceleration due to gravity	:	$g = 9.8\,\mathrm{m/s^2}$
Universal gas constant	:	$R = 8.31\,\mathrm{J/mol\,K}$
Boltzmann constant	:	$k = 1.38 \times 10^{-23}\,\mathrm{J/K}$
Atmospheric pressure (at STP)	:	$1\,\mathrm{atm} = 1.01 \times 10^{5}\,\mathrm{Pa}$
Universal gravitational constant	:	$G = 6.67 \times 10^{-11}\,\mathrm{N m^2/kg^2}$
Permeability of free space	:	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H/m}$
Permeability of free space	:	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H/m}$
Avogadro's constant	:	$N_A = 6.02 \times 10^{-23}$
Speed of light in free space	:	$c = 3 \times 10^{8}\,\mathrm{m/s}$
Speed of sound in dry air at 0°C	:	$v_0 = 332\,\mathrm{m/s}$
Stefan's constant	:	$\sigma = 5.67 \times 10^{-8}\,\mathrm{W/m^2K^4}$
Planck's constant	:	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
Faraday constant	:	$F = 96\,500\,\mathrm{C/mol}$

PART–A

ONLY ONE out of four options is correct. Bubble the correct option.

1. The ground state energy of an electron in the hydrogen atom is -13.6 eV. The kinetic energy of an electron in the first excited state ($n = 2$) of the hydrogen atom is

   A. +13.6 eV B. -13.6 eV **C. +3.4 eV** D. -3.4 eV

2. A ring, a disk a solid sphere and a solid cylinder, all of the same mass M are made to race down an inclined surface. Which one of them would lose the race?

   A. Ring. B. Disk. C. Sphere. D. Cylinder.

3. When heat Q is supplied to a gas, part of it increases its internal energy and part does external work. This statement mathematically defines:

   A. Clausius theorem B. Kelvin–Planck statement **C. First law of thermodynamics** D. Second law of thermodynamics

4. Which of the following statements correctly explains why iron (^{56}Fe) is one of the most stable nuclei in nature?

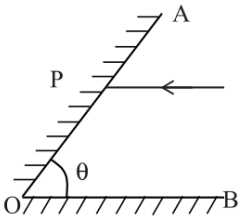
   A. Because iron has the highest mass number among naturally occurring elements.

   B. Because iron has the maximum number of neutrons per proton in all nuclei.

   C. Because iron has the highest binding energy per nucleon, making further fission or fusion energetically unfavorable.

   D. Because iron has zero mass defect, so it cannot undergo any nuclear reaction.

5. Two plane mirrors OA and OB are aligned with respect to each other at an angle θ. When a ray of light that is initially parallel to the mirror OB is incident on the mirror OA at the point P, the reflected ray gets reflected again from the mirror OB and finally emerges parallel to the mirror OA. What might be the value of the angle θ?



   A. 30° B. 45° **C.** 60° D. 75°

6. Sunlight is scattered by molecules in the atmosphere due to a process called Rayleigh scattering. If the intensity of scattered light at wavelength 400 nm is I_0, the intensity at wavelength 800 nm, for the same incident flux and same scattering geometry, is approximately

   A. $I_0/2$ B. $I_0/4$ C. $I_0/8$ **D.** $I_0/16$

7. A resistance of 40Ω is connected to a source of alternating current rated 220 V, 50Hz. The time taken by the current to change from its maximum value to the rms value is

   A. 2.5 S B. 0.25 S **C. 2.5 mS** D. 1.5 mS

8. Assuming the earth to be a sphere of uniform mass density, how much would a body weigh half way down to the centre of the earth if it weighed 200 N on the surface?

   A. 50 N B. 200 N **C. 100 N** D. 400 N

9. Two thin lenses L_1 and L_2 (both thin and coaxial) are separated by 30 cm. L_1 and L_2 have focal lengths of +20 cm and +30 cm respectively. An object is placed 40 cm in front of L_1. The final image is formed at a distance from L_2 approximately equal to

   A. −7.5 cm B. −4.0 cm **C.** +7.5 cm D. +4.0 cm

10. A marble block of mass 10 kg lying on ice when given a velocity of $5m/s$ is stopped by friction in $10s$. Then the coefficient of friction is (consider $g = 10m/s$)

    A. 0.5 B. 0.25 C. 0.005 **D. 0.05**

11. How would you determine if an AC circuit is capacitive in nature?

    A. I **leads** V B. V leads I C. V and I are in-phase. D. V and I are out-of-phase.

12. According to the first law of thermodynamics, during a phase change, such as melting or boiling, the supplied heat is utilized in

A. Increasing the temperature of the substance

B. Increasing only kinetic energy, not the potential energy

C. Increasing only the internal potential energy, not the kinetic energy

D. The heat supplied is completely lost to the surroundings

13. Two point charges are placed within an oil whose dielectric constant is κ. The Coulomb force between them will

A. Increase by κ. **B. Decrease by κ.**
C. Increase by κ^2. D. Decrease by κ^2.

14. The ratio of the kinetic energy required to be given to the satellite to escape Earth's gravitational field to the Kinetic energy required to be given so that the satellite moves in a circular orbit just above earth atmosphere is

A. 1:2 B. 1:3 C. 3:1 **D. 2:1**

15. Why does an LED emit light when forward biased, but a normal silicon diode does not?

A. LEDs allow current only in reverse bias, while silicon diodes allow it in forward bias.

B. In LEDs, electron–hole recombination releases energy in the form of visible light.

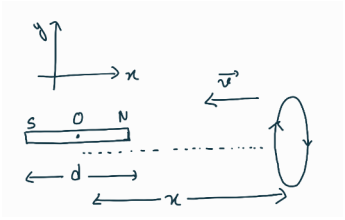
C. Silicon diodes absorb light instead of emitting it.

D. LEDs do not have a depletion region like silicon diodes.

16. A person is prescribed a concave lens of power -0.25 dioptres to correct his myopia for distant vision. What is the maximum distance he could see clearly unaided by the lens?

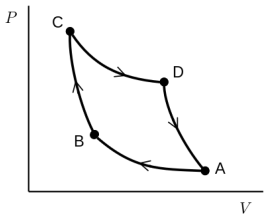
A. 2 m **B.** 4 m C. 6 m D. 8 m

17. The magnetic field due to a magnetic dipole lying in the x axis at an axial point at a sufficiently large distance $x >> d$ from its centre can be approximated to be $\vec{B} \simeq \frac{\mu_0}{4\pi}\frac{2\vec{p}}{x^3}\hat{i}$ ($\vec{p}$ is the dipole moment of the magnetic dipole). A circular loop of area of cross section A is moving towards the dipole with a uniform velocity $\vec{v}$. The induced e.m.f. on the circular loop when it is at a distance x is



A. 0 **B.** $-\frac{3BAv}{x}$ C. $-\frac{3BAv}{4x}$
D. $-\frac{3BAv}{2x}$

18. In the Carnot cycle shown below, it is given that $P_A = 2$ atm, $P_B = 6$ atm and $P_C = 24$ atm. If $V_A = 1$ L and the adiabatic index of the gas is $\gamma = 2$, then what is the value of V_C?



A. 1/2 L B. 1/3 L **C.** 1/6 L D. 1/12 L

19. Imagine sending information over long distances, not by electric wires but by pulses of light, as fast as possible, with almost no loss. That's what optical fibres do – they are like hair-thin tunnels of glass or plastic that act as such "wires" for light. Which physical principle allows optical fibres to guide light without escaping through their walls?

A. Interference of light

B. Diffraction of light

C. Inelastic scattering of light

D. Total internal reflection of light

20. A conductor of made up of copper has a length l and area of cross section A . It's resistivity is ρ_0 at 25^0C. What would be the percentage increase in it's resistance at 30^0C? (The temperature coefficient of resistivity of copper is $\alpha = 0.004^0\text{C}^{-1}$)

A. 4% **B.** 2% C. 1% D. 0%

21. A spherical container with expandable surface contains an ideal gas at temperature T. If the temperature is increased to $8T$, by what factor radius of the container would change

A. increases 4 times **B. increases 2 times**
C. decreases to 1/4 D. decreases to 1/2

22. A thin converging lens produces a real image whose size is twice the size of the object. When the object is moved 10 cm closer to the lens, the real image becomes thrice the size of the object. The focal length of the lens is

A. 30 cm B. 40 cm C. 50 cm **D.** 60 cm

23. Which of the following are considered to be important factors for the origin of life on the Earth?

A. The anomalous behaviour of water.

B. The high specific heat capacity of water.

C. The polarity of the water molecule.

D. All of the above.

24. A solid cylinder of mass M and radius R rolls without slipping down an inclined plane of angle 30°. The linear acceleration of its centre of mass is a. If the same cylinder slides without friction, its acceleration is a'. What is the ratio a/a'?

A. $\frac{1}{3}$ B. $\frac{1}{4}$ C. $\frac{3}{2}$ **D.** $\frac{2}{3}$

25. A capacitor of capacitance C is connected to a battery of potential difference V. The energy stored in it is E. If another capacitor of capacitance $2C$ is connected in series with the first capacitor (while both remain connected to the same battery), what will be the total energy stored in the combination?

A. $3E$ **B.** $\frac{2}{3}E$ C. $\frac{3}{2}E$ D. $\frac{1}{3}E$

26. A bi-convex glass lens has refractive index $\mu_g = 1.5$ and focal length 20 cm in air. The same lens is immersed in a liquid of refractive index $\mu_l = 1.2$. Then the focal length of the lens in the liquid becomes

A. 10 cm B. 20 cm **C.** 40 cm D. 80 cm

27. A block of mass 2kg is attached to a light spring of force constant 200N/m and placed on a smooth horizontal surface. The block is pulled to stretch the spring by 5cm and released from rest. What is the maximum speed of the block during its motion?

A. 0.25 m/S B. 0.35 m/S **C. 0.50 m/S** D. 1 m/S

28. When an ambulance with its siren on comes towards you and then goes away, what changes in the sound you hear?

A. The sound becomes higher in pitch as it comes closer and lower in pitch as it goes away.

B. The sound travels faster towards you and slower when moving away.

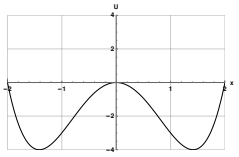
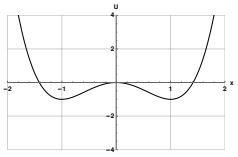
C. The pitch is lowest when the ambulance is right in front of you.

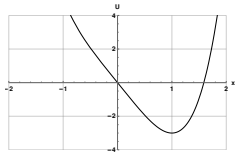
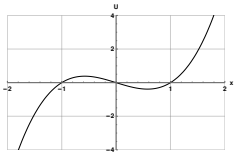
D. Only loudness changes; pitch remains the same.

29. The escape speed of a projectile on the earth's surface is v_e. A body is projected out with thrice this speed. What is the speed of the body far away from the earth? Ignore the presence of the sun and other planets.

A. $2v_e$ **B.** $2\sqrt{2}v_e$ C. $\sqrt{2}v_e$ D. $v_e/\sqrt{2}$

30. A particle is under the influence of the one dimensional potential $U = -2x^2 + x^4$. Which of the following plot best describes the potential

A.  **B.** 

C.  D. 

31. A prism of apex angle $A = 60°$ is made from glass with refractive index $\mu = 1.5$. For a monochromatic ray the prism is used in the condition of minimum deviation. Then the angle of minimum deviation δ_m is approximately [use $\sin^{-1}(0.75) \approx 48.6$]

A. 11.4° B. 35.7° **C.** 37.2° D. 78.6°

32. On shining a faint red light on a metal surface, nothing happens. In order for photoelectrons to be ejected from the metal surface,

A. The brighness of the red light must be increased.

B. The metal surface must be heated before shining red light.

C. The metal surface must be rubbed with a woolen cloth to increase its number of electrons.

D. Blue light should be used instead of red light.

33. An observer stands on the platform at the front edge of the first bogie of a stationary

train. The train starts moving with uniform acceleration and the first bogie takes 5 seconds to cross the observer. If all the bogies of the train are of equal length and the gap between them is negligible, the time taken by the tenth bogie to cross the observer is

A. 1.07 s B. 0.94 s C. 0.91 s **D. 0.81 s**

34. A baby is sitting on the principal axis of a convex mirror of focal length f, at a distance $2f$ from the pole in front of the mirror. She starts crawling on principal axis towards the mirror. During the course of her motion, the distance between the baby and her image

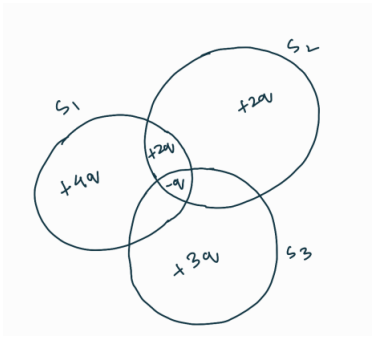
A. Always decreases.

B. Always increases.

C. First decreases, then increases.

D. First increases, then decreases.

35. What is the correct ratio of the electric flux passing through the surface S_1, S_2 and S_3 is



A. 4:2:3 **B. 5:3:2** C. 6:3:2 D. 6:4:2

36. A cylindrical block of wood of mass M, length L and radius R is floating in water of density ρ. If it is depressed a little, the block undergoes simple harmonic motion. Ignore viscosity. Acceleration due to gravity is g. The angular frequency of oscillation is

A. $\sqrt{\frac{\pi R^2 \rho g}{M}}$ B. $\sqrt{\frac{g}{L}}$ C. $\sqrt{\frac{\pi R^3 \rho g}{ML}}$ D. $\sqrt{\frac{L^2 \rho g}{M}}$

37. Four students throw darts at a target. Their results are shown below:

Case I: All darts are very close to the centre.

Case II: All darts are clustered together but far from the centre.

Case III: Darts are scattered all around but their average position is near the centre.

Case IV: Darts are scattered randomly and far from the centre.

Which of the following matches the correct interpretation?

- I = High accuracy, high precision
- II = Low accuracy, high precision
- III = High accuracy, low precision
- IV = Low accuracy, low precision

Choose the correct option:

A. I and II only

B. I, II, and III only

C. All of I, II, III, and IV

D. Only I is correct

38. A simple pendulum, consisting of a light inextensible string of length attached to a small heavy bob of mass m, is at rest. The bob is imparted a horizontal impulsive force which gives it a velocity of $\sqrt{4gl}$. The speed of the bob at its highest point is

A. 0 B. $\sqrt{\frac{gl}{3}}$ C. $\sqrt{\frac{2gl}{3}}$ D. $\sqrt{\frac{8gl}{27}}$

39. A ball of mass m falls from a height h on a vertical spring of spring constant k whose bottom end is fixed to ground. Neglecting the length of the spring compared to the height h the displacement of the spring from its equilibrium position would be

A. $\sqrt{\frac{mgh}{k}}$ B. $\sqrt{\frac{2mgh}{k}}$ **C.** $\frac{mg}{k}\left(1+\sqrt{1+\frac{2kh}{mg}}\right)$ D. $\frac{mg}{k}\left(1+\sqrt{1+\frac{kh}{mg}}\right)$

40. The refractive index of glass with respect to air is 3/2, while that of water is 4/3. Which of the following statements correctly describes the condition for the critical angle (i_c) at the glass–water interface?

A. $0^0 \le i_c \le 30^0$ B. $30^0 \le i_c \le 45^0$ C. $45^0 \le i_c \le 60^0$ **D.** $45^0 \le i_c \le 90^0$

41. In an electrical circuit two resistors of 2Ω and 4Ω respectively are connected in series to a 6 V battery. The heat dissipated by the 4Ω resistor in 5 s will be

A. 5 J B. 10 J **C. 20 J** D. 30 J

42. A string of length L is fixed at both ends and set into vibration. A standing wave is formed with three anti-nodes. Which statement is correct about the frequency of this mode?

A. It is the fundamental frequency.

B. It is the second harmonic.

C. It is the first overtone.

D. Its frequency is three times the fundamental frequency.

43. A beetle flies and lands on a twig 10 cm away from the focus of a thin convex lens on its principal axis. On a wall 40 cm away from the focus on the other side of the lens, a sharp and inverted image of the beetle is formed. What might be the focal length of the lens?

A. 20 cm B. 30 cm C. 40 cm D. 60 cm

44. The moment of inertia of a semicircular disc of mass M and radius R is

A. MR^2 B. $\frac{MR^2}{2}$ C. $\frac{MR^2}{4}$ D. $2MR^2$

45. At a particular instant of time, a charged particle, within a region of crossed E and B fields, is observed to move perpendicular to the plane containing both fields and with a speed that is exactly equal to $v = E/B$. The shape of the particles path is

A. Linear B. Circular C. Helical D. Cycloidal

46. A doctor uses ultrasound to examine internal organs because:

A. Ultrasound travels slower than normal sound.

B. Ultrasound gets completely absorbed by bones.

C. Ultrasound can reflect from boundaries inside the body.

D. Human ears can hear ultrasound clearly.

47. The maximum error in the measurement of resistance, current and time for which the current is flowing through the circuit is 1%, 2% and 3% respectively. The maximum percentage error in the measurement of heat dissipated will be A. 2% B. 4% C. 6% **D.** 8%

48. A mass of 4kg rests on a horizontal plane. The plane is gradually inclined until at an angle $\theta = 30^0$ with the horizontal, the mass just begins to slide. What is the coefficient of static friction between the block and the surface ?

A. $1/2$ B. $1/\sqrt{2}$ C. $1/3$ **D.** $1/\sqrt{3}$

PART–B

MORE THAN ONE options may be correct. Marks will be awarded only if all of the correct options are bubbled.

49. As the temperature increases, the behaviour of electrical resistance differs for conductors and semiconductors. Which of the following statements is/are correct?

A. For a metallic conductor, R increases with T

B. For a semiconductor, R decreases with T

C. In conductors, increase in R with T is due to increased lattice vibrations.

D. The T coefficient of R for a semiconductor is negative.

50. Two small stars of masses M_1 and M_2 initially far apart are at rest. The stars move towards each other under gravitational attraction. The velocity of approach, when the two stars are a distance d apart, is equal to

A. $\sqrt{\frac{GM_1}{d}} + \sqrt{\frac{GM_2}{d}}$ **B.** $\sqrt{\frac{G(M_1+M_2)}{d}}$

C. $\sqrt{\frac{2GM_1}{d}} + \sqrt{\frac{2GM_2}{d}}$ D. $\sqrt{\frac{2G}{\left(\frac{1}{M_1}+\frac{1}{M_2}\right)d}}$

51. A block of mass m is pushed along a rough horizontal surface by a constant horizontal force F for a distance s. The coefficient of kinetic friction between the block and the surface is μ

Which of the following statements is/are correct?

A. The work done by the frictional force is $-\mu mgs$

B. The change is kinetic energy of the block is $Fs - \mu mgs$

C. If $F = \mu mg$ the blocks move with constant velocity

D. The net work done on the block is zero only if $F = 0$

52. Two wires A and B made of the same material have the same length but different radii r_A and r_B ($r_B = 2r_A$). Both are connected in parallel across a battery of emf E with negligible internal resistance. If the total power dissipated in the combination is P, what fraction of the total power is dissipated in wire A?

A. $\frac{1}{5}P$ B. $\frac{1}{4}P$ C. $\frac{1}{3}P$ D. $\frac{1}{2}P$

53. A long straight wire carrying a steady current

I lies along the z-axis. A square loop of side a, carrying a current I', lies in the xy-plane such that its nearest side is at a distance r from the wire ($a << r$).

Consider only the magnetic interaction between the wire and the loop.

Which of the following statements are correct?

A. The magnitude of the magnetic force on the nearer side of the loop is greater than that on the farther side..

B. If the currents I and I' flow in the same sense (as seen from $+z$), the net force on the loop is towards the wire (i.e. attractive).

C. The net torque on the loop about the z-axis (the axis of the straight wire) is zero.

D. The loop experiences a net force perpendicular to the xy-plane (i.e. a net force along z).

54. A transparent right-angled triangular prism ABC, with BC as its hypotenuse, is placed in air. A ray incident on the face AB and travelling parallel to the hypotenuse emerges from the face AC grazing the surface, whereas a ray incident on the face AC and also parallel to the hypotenuse is totally internally reflected at the face AB. The range of values of the refractive index μ of the prism material is

A. $\mu > 2$ B. $\mu < \sqrt{\frac{3}{2}}$ C. $\sqrt{2} < \mu < \sqrt{3}$

D. $\sqrt{\frac{3}{2}} < \mu < \sqrt{2}$

55. Two thin coaxial lenses L_1 and L_2 are placed in contact. Their focal lengths and powers are f_1, f_2 and P_1, P_2 respectively. If the effective focal length is F, which of the following statements are correct?

A. If f_1 and f_2 are both positive, the effective focal length F equals $f_1 + f_2$.

B. The effective power of the combination is $P = P_1 + P_2$.

C. If $f_1 = -f_2$, the combination is afocal.

D. If both f_1 and f_2 are positive, the effective focal length F is always larger than the larger of f_1 and f_2.

56. A thin symmetric bi-convex glass lens of refractive index μ_l is placed in a surrounding medium of refractive index μ_m. Which of the following statements are necessarily true (for arbitrary curvatures, assuming thin-lens approximation)?

A. If $\mu_l \to \mu_m$, $f \to \infty$

B. If $\mu_m > \mu_l$, it becomes diverging

C. Immersing the lens in a medium with μ decreases $|f|$.

D. If $\mu_e l = 1.5$, $\mu_m = 1.2$, the f increases.

57. An incompressible, non-viscous fluid of density ρ steadily flows through a horizontal pipe from cross-sectional area decreases from A_1 to A_2 ($A_1 > A_2$). The pressure and velocity of the fluid while passing through the area A_1 are P_1 and v_1, respectively. The pressure at the cross-sectional area A_2 is

A. $P_1 + \frac{1}{2}\rho\left(1 - \frac{A_2^2}{A_1^2}v_1^2\right)$ **B.** $P_1 + \frac{1}{2}\rho\left(1 - \frac{A_1^2}{A_2^2}\right)v_1^2$

C. $P_1 + \frac{1}{2}\rho\left(1 - \frac{A_1^2}{A_2^2}v_1^2\right)$ D. $P_1 + \frac{1}{2}\rho\left(1 - \frac{A_2^2}{A_1^2}\right)v_1^2$

58. A thin double convex lens of radii of curvature $R_1 = 20\,\text{cm}$ and $R_2 = 60\,\text{cm}$ is made-up of glass with refractive index $\mu = 1.5$. Let the focal length of the lens be f. Choose the correct option(s)

A. In air, $f = 30\,\text{cm}$.

B. The lens behaves as a concave mirror $f_M = 10\,\text{cm}$ when silvered on the R_2 surface.

C. The lens behaves as a concave lens if beyond R_2 surface is filled with a transparent liquid with $\mu = 5/3$.

D. A beam of rays incident parallel to principal axis never focuses behind the lens.

59. A ball of mass m is falling from the top of a multi story building of height h. Which of the following statements are correct about the motion of the ball? (Neglect the air resistance)

A. v increases linearly with t

B. s vs v graph is parabolic

C. mgh equals total K.E. before hitting the ground

D. K.E. linearly increases with t

60. A battery of emf 12 V and internal resistance 1 Ω is connected in series with a resistor $R_1 = 3\Omega$. Across the terminals of R_1, a parallel branch is connected that contains two resistors $R_2 = 6\Omega$ and $R_3 = 3\Omega$ in series. Find the current supplied by the battery (in amperes).

A. $1.2A$ B. $1.5A$ **C.** $1.6A$ D. $1.8A$

***** $\varepsilon\eta\delta$ *****

PHYSICS ACADEMY OF NORTH EAST
North East India Physics Talent Search 2025

Date of examination: *9 Nov. 2025*
Time: 10:00 AM to 12:00 PM
Maximum marks: 216

Candidate's Roll Number: | | | | | | **Serial No.:**

Code: C

Instructions to candidates

1. Use of smart devices of any kind during the examination is **STRICTLY PROHIBITED**.
2. Use of non-programmable scientific calculator is allowed.
3. In addition to this question booklet, you are provided with an OMR response sheet.
4. On the OMR response sheet, make all the entries carefully in the space provided ONLY in BLOCK CAPITALS as well as by properly darkening the appropriate bubbles. Incomplete/incorrect/carelessly filled information may disqualify your candidature.
5. On the OMR response sheet, use only BLUE or BLACK BALL POINT PEN for making entries and bubbling the answers.
6. In part A, from questions numbered 1 to 48, each question has four alternatives, out of which only one is correct. Choose the correct alternative and fill the appropriate bubble.
7. In part B, from questions numbered 49 to 60, each question has four alternatives, out of which any number of alternatives is correct. Choose **all** the correct alternatives and fill the appropriate bubbles.
8. In part A, each correct answer carries 3 marks whereas 1 mark will be deducted for each wrong answer. In part B, 6 marks will be awarded if all the correct alternatives are marked. There is no negative marking in this part.
9. No candidate should leave the examination hall before the completion of the examination.
10. After submitting OMR response sheet, the candidate may carry with them the question booklet.
11. Please DO NOT make any mark other than filling the appropriate bubbles properly in the space provided on the OMR response sheet.
12. OMR response sheets are generally machine-evaluated, hence CHANGE OF ENTRY IS NOT ALLOWED. Scratching or overwriting may result in a wrong score.
13. Do not write on the back side of the response sheet.

Physical constants you may need

Magnitude of charge on electron	:	$e = 1.6 \times 10^{-19}\,\mathrm{C}$
Mass of electron	:	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
Mass of proton	:	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
Acceleration due to gravity	:	$g = 9.8\,\mathrm{m/s^2}$
Universal gas constant	:	$R = 8.31\,\mathrm{J/mol\,K}$
Boltzmann constant	:	$k = 1.38 \times 10^{-23}\,\mathrm{J/K}$
Atmospheric pressure (at STP)	:	$1\,\mathrm{atm} = 1.01 \times 10^{5}\,\mathrm{Pa}$
Universal gravitational constant	:	$G = 6.67 \times 10^{-11}\,\mathrm{N m^2/kg^2}$
Permeability of free space	:	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H/m}$
Permeability of free space	:	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H/m}$
Avogadro's constant	:	$N_A = 6.02 \times 10^{-23}$
Speed of light in free space	:	$c = 3 \times 10^{8}\,\mathrm{m/s}$
Speed of sound in dry air at 0°C	:	$v_0 = 332\,\mathrm{m/s}$
Stefan's constant	:	$\sigma = 5.67 \times 10^{-8}\,\mathrm{W/m^2K^4}$
Planck's constant	:	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
Faraday constant	:	$F = 96\,500\,\mathrm{C/mol}$

PART–A

ONLY ONE out of four options is correct. Bubble the correct option.

1. A block of mass 2kg is attached to a light spring of force constant 200N/m and placed on a smooth horizontal surface. The block is pulled to stretch the spring by 5cm and released from rest. What is the maximum speed of the block during its motion?

   A. 0.25 m/S B. 0.35 m/S **C. 0.50 m/S** D. 1 m/S

2. At a particular instant of time, a charged particle, within a region of crossed E and B fields, is observed to move perpendicular to the plane containing both fields and with a speed that is exactly equal to $v = E/B$. The shape of the particles path is

   A. Linear B. Circular C. Helical D. Cycloidal

3. A marble block of mass 10 kg lying on ice when given a velocity of $5m/s$ is stopped by friction in $10s$. Then the coefficient of friction is (consider $g = 10m/s$)

   A. 0.5 B. 0.25 C. 0.005 **D. 0.05**

4. A cylindrical block of wood of mass M, length L and radius R is floating in water of density ρ. If it is depressed a little, the block undergoes simple harmonic motion. Ignore viscosity. Acceleration due to gravity is g. The angular frequency of oscillation is

   A. $\sqrt{\frac{\pi R^2 \rho g}{M}}$ B. $\sqrt{\frac{g}{L}}$ C. $\sqrt{\frac{\pi R^3 \rho g}{ML}}$ D. $\sqrt{\frac{L^2 \rho g}{M}}$

5. A person is prescribed a concave lens of power -0.25 dioptres to correct his myopia for distant vision. What is the maximum distance he could see clearly unaided by the lens?

   A. 2m **B.** 4m C. 6m D. 8m

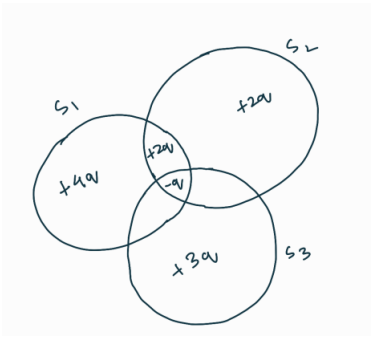
6. Sunlight is scattered by molecules in the atmosphere due to a process called Rayleigh scattering. If the intensity of scattered light at wavelength 400 nm is I_0, the intensity at wavelength 800 nm, for the same incident flux and same scattering geometry, is approximately

   A. $I_0/2$ B. $I_0/4$ C. $I_0/8$ **D.** $I_0/16$

7. The ground state energy of an electron in the hydrogen atom is -13.6 eV. The kinetic energy of an electron in the first excited state ($n = 2$) of the hydrogen atom is

   A. +13.6 eV B. -13.6 eV **C. +3.4 eV** D. -3.4 eV

8. What is the correct ratio of the electric flux passing through the surface S_1, S_2 and S_3 is



   A. 4:2:3 **B. 5:3:2** C. 6:3:2 D. 6:4:2

9. A baby is sitting on the principal axis of a convex mirror of focal length f, at a distance $2f$ from the pole in front of the mirror. She starts crawling on principal axis towards the mirror. During the course of her motion, the distance between the baby and her image

   A. Always decreases.

   B. Always increases.

   C. First decreases, then increases.

   D. First increases, then decreases.

10. A solid cylinder of mass M and radius R rolls without slipping down an inclined plane of angle 30°. The linear acceleration of its centre of mass is a. If the same cylinder slides without friction, its acceleration is a'. What is the ratio a/a'?

    A. $\frac{1}{3}$ B. $\frac{1}{4}$ C. $\frac{3}{2}$ **D.** $\frac{2}{3}$

11. A spherical container with expandable surface contains an ideal gas at temperature T. If the temperature is increased to $8T$, by what factor radius of the container would change

    A. increases 4 times **B. increases 2 times** C. decreases to 1/4 D. decreases to 1/2

12. A ring, a disk a solid sphere and a solid cylinder, all of the same mass M are made to race down an inclined surface. Which one of them would lose the race?

    A. Ring. B. Disk. C. Sphere. D. Cylinder.

13. A ball of mass m falls from a height h on a vertical spring of spring constant k whose bottom end is fixed to ground. Neglecting the length of the spring compared to the height h the displacement of the spring from its equilibrium position would be

A. $\sqrt{\frac{mgh}{k}}$ B. $\sqrt{\frac{2mgh}{k}}$ **C.** $\frac{mg}{k}\left(1+\sqrt{1+\frac{2kh}{mg}}\right)$ D. $\frac{mg}{k}\left(1+\sqrt{1+\frac{kh}{mg}}\right)$

14. Assuming the earth to be a sphere of uniform mass density, how much would a body weigh half way down to the centre of the earth if it weighed 200 N on the surface?

A. 50 N B. 200 N **C. 100 N** D. 400 N

15. When an ambulance with its siren on comes towards you and then goes away, what changes in the sound you hear?

A. The sound becomes higher in pitch as it comes closer and lower in pitch as it goes away.

B. The sound travels faster towards you and slower when moving away.

C. The pitch is lowest when the ambulance is right in front of you.

D. Only loudness changes; pitch remains the same.

16. A bi-convex glass lens has refractive index $\mu_g = 1.5$ and focal length 20 cm in air. The same lens is immersed in a liquid of refractive index $\mu_l = 1.2$. Then the focal length of the lens in the liquid becomes

A. 10 cm B. 20 cm **C.** 40 cm D. 80 cm

17. According to the first law of thermodynamics, during a phase change, such as melting or boiling, the supplied heat is utilized in

A. Increasing the temperature of the substance

B. Increasing only kinetic energy, not the potential energy

C. Increasing only the internal potential energy, not the kinetic energy

D. The heat supplied is completely lost to the surroundings

18. Why does an LED emit light when forward biased, but a normal silicon diode does not?

A. LEDs allow current only in reverse bias, while silicon diodes allow it in forward bias.

B. In LEDs, electron–hole recombination releases energy in the form of visible light.

C. Silicon diodes absorb light instead of emitting it.

D. LEDs do not have a depletion region like silicon diodes.

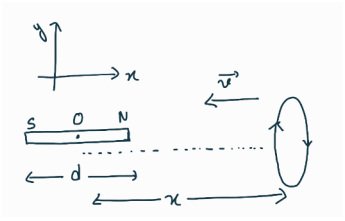
19. A capacitor of capacitance C is connected to a battery of potential difference V. The energy stored in it is E. If another capacitor of capacitance $2C$ is connected in series with the first capacitor (while both remain connected to the same battery), what will be the total energy stored in the combination?

A. $3E$ **B.** $\frac{2}{3}E$ C. $\frac{3}{2}E$ D. $\frac{1}{3}E$

20. How would you determine if an AC circuit is capacitive in nature?

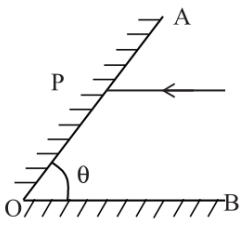
A. I **leads** V B. V leads I C. V and I are in-phase. D. V and I are out-of-phase.

21. The magnetic field due to a magnetic dipole lying in the x axis at an axial point at a sufficiently large distance $x >> d$ from its centre can be approximated to be $\vec{B} \simeq \frac{\mu_0}{4\pi}\frac{2\vec{p}}{x^3}\hat{i}$ ($\vec{p}$ is the dipole moment of the magnetic dipole). A circular loop of area of cross section A is moving towards the dipole with a uniform velocity $\vec{v}$. The induced e.m.f. on the circular loop when it is at a distance x is



A. 0 **B.** $-\frac{3BAv}{x}$ C. $-\frac{3BAv}{4x}$ D. $-\frac{3BAv}{2x}$

22. Two plane mirrors OA and OB are aligned with respect to each other at an angle θ. When a ray of light that is initially parallel to the mirror OB is incident on the mirror OA at the point P, the reflected ray gets reflected again from the mirror OB and finally emerges parallel to the mirror OA. What might be the value of the angle θ?



A. 30° B. 45° **C.** 60° D. 75°

23. Which of the following are considered to be important factors for the origin of life on the Earth?

A. The anomalous behaviour of water.

B. The high specific heat capacity of water.

C. The polarity of the water molecule.

D. All of the above.

24. Which of the following statements correctly explains why iron (^{56}Fe) is one of the most stable nuclei in nature?

A. Because iron has the highest mass number among naturally occurring elements.

B. Because iron has the maximum number of neutrons per proton in all nuclei.

C. Because iron has the highest binding energy per nucleon, making further fission or fusion energetically unfavorable.

D. Because iron has zero mass defect, so it cannot undergo any nuclear reaction.

25. The moment of inertia of a semicircular disc of mass M and radius R is

A. MR^2 B. $\frac{MR^2}{2}$ C. $\frac{MR^2}{4}$ D. $2MR^2$

26. A resistance of 40Ω is connected to a source of alternating current rated 220 V, 50Hz. The time taken by the current to change from its maximum value to the rms value is

A. 2.5 S B. 0.25 S **C. 2.5 mS** D. 1.5 mS

27. On shining a faint red light on a metal surface, nothing happens. In order for photoelectrons to be ejected from the metal surface,

A. The brighness of the red light must be increased.

B. The metal surface must be heated before shining red light.

C. The metal surface must be rubbed with a woolen cloth to increase its number of electrons.

D. Blue light should be used instead of red light.

28. The escape speed of a projectile on the earth's surface is v_e. A body is projected out with thrice this speed. What is the speed of the body far away from the earth? Ignore the presence of the sun and other planets.

A. $2v_e$ **B.** $2\sqrt{2}v_e$ C. $\sqrt{2}v_e$ D. $v_e/\sqrt{2}$

29. Two thin lenses L_1 and L_2 (both thin and coaxial) are separated by 30 cm. L_1 and L_2 have focal lengths of +20 cm and +30 cm respectively. An object is placed 40 cm in front of L_1. The final image is formed at a distance from L_2 approximately equal to

A. −7.5 cm B. −4.0 cm **C.** +7.5 cm D. +4.0 cm

30. A string of length L is fixed at both ends and set into vibration. A standing wave is formed with three anti-nodes. Which statement is correct about the frequency of this mode?

A. It is the fundamental frequency.

B. It is the second harmonic.

C. It is the first overtone.

D. Its frequency is three times the fundamental frequency.

31. A mass of 4kg rests on a horizontal plane. The plane is gradually inclined until at an angle $\theta = 30^0$ with the horizontal, the mass just begins to slide. What is the coefficient of static friction between the block and the surface ?

A. 1/2 B. $1/\sqrt{2}$ C. 1/3 **D.** $1/\sqrt{3}$

32. Four students throw darts at a target. Their results are shown below:

Case I: All darts are very close to the centre.

Case II: All darts are clustered together but far from the centre.

Case III: Darts are scattered all around but their average position is near the centre.

Case IV: Darts are scattered randomly and far from the centre.

Which of the following matches the correct interpretation?

- I = High accuracy, high precision
- II = Low accuracy, high precision
- III = High accuracy, low precision

- IV = Low accuracy, low precision

Choose the correct option:

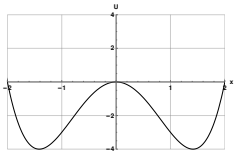
A. I and II only

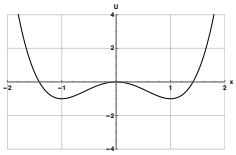
B. I, II, and III only

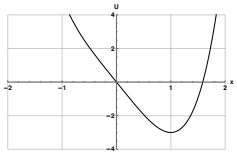
C. All of I, II, III, and IV

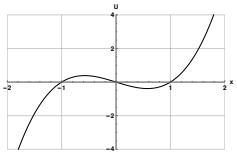
D. Only I is correct

33. A particle is under the influence of the one dimensional potential $U = -2x^2 + x^4$. Which of the following plot best describes the potential

A. 

B. 

C. 

D. 

34. A conductor of made up of copper has a length l and area of cross section A . It's resistivity is ρ_0 at 25^0C. What would be the percentage increase in it's resistance at 30^0C? (The temperature coefficient of resistivity of copper is $\alpha = 0.004^0\text{C}^{-1}$)

A. 4% **B.** 2% C. 1% D. 0%

35. Imagine sending information over long distances, not by electric wires but by pulses of light, as fast as possible, with almost no loss. That's what optical fibres do – they are like hair-thin tunnels of glass or plastic that act as such "wires" for light. Which physical principle allows optical fibres to guide light without escaping through their walls?

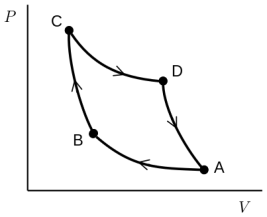
A. Interference of light

B. Diffraction of light

C. Inelastic scattering of light

D. Total internal reflection of light

36. In the Carnot cycle shown below, it is given that $P_A = 2$ atm, $P_B = 6$ atm and $P_C = 24$ atm. If $V_A = 1$ L and the adiabatic index of the gas is $\gamma = 2$, then what is the value of V_C?



A. 1/2 L B. 1/3 L **C.** 1/6 L D. 1/12 L

37. A simple pendulum, consisting of a light inextensible string of length attached to a small heavy bob of mass m, is at rest. The bob is imparted a horizontal impulsive force which gives it a velocity of $\sqrt{4gl}$. The speed of the bob at its highest point is

A. 0 B. $\sqrt{\frac{gl}{3}}$ C. $\sqrt{\frac{2gl}{3}}$ D. $\sqrt{\frac{8gl}{27}}$

38. A beetle flies and lands on a twig 10 cm away from the focus of a thin convex lens on its principal axis. On a wall 40 cm away from the focus on the other side of the lens, a sharp and inverted image of the beetle is formed. What might be the focal length of the lens?

A. 20 cm B. 30 cm C. 40 cm D. 60 cm

39. A thin converging lens produces a real image whose size is twice the size of the object. When the object is moved 10 cm closer to the lens, the real image becomes thrice the size of the object. The focal length of the lens is

A. 30 cm B. 40 cm C. 50 cm **D.** 60 cm

40. An observer stands on the platform at the front edge of the first bogie of a stationary train. The train starts moving with uniform acceleration and the first bogie takes 5 seconds to cross the observer. If all the bogies of the train are of equal length and the gap between them is negligible, the time taken by the tenth bogie to cross the observer is

A. 1.07 s B. 0.94 s C. 0.91 s **D. 0.81 s**

41. In an electrical circuit two resistors of 2Ω and 4Ω respectively are connected in series to a 6 V battery. The heat dissipated by the 4Ω resistor in 5 s will be

A. 5 J B. 10 J **C. 20 J** D. 30 J

42. Two point charges are placed within an oil whose dielectric constant is κ. The Coulomb force between them will

A. Increase by κ. **B. Decrease by κ.**
C. Increase by κ^2. D. Decrease by κ^2.

43. When heat Q is supplied to a gas, part of it increases its internal energy and part does external work. This statement mathematically defines:

A. Clausius theorem B. Kelvin–Planck statement **C. First law of thermodynamics** D. Second law of thermodynamics

44. The maximum error in the measurement of resistance, current and time for which the current is flowing through the circuit is 1%, 2% and 3% respectively. The maximum percentage error in the measurement of heat dissipated will be A. 2% B. 4% C. 6% **D.** 8%

45. A doctor uses ultrasound to examine internal organs because:

A. Ultrasound travels slower than normal sound.

B. Ultrasound gets completely absorbed by bones.

C. Ultrasound can reflect from boundaries inside the body.

D. Human ears can hear ultrasound clearly.

46. The ratio of the kinetic energy required to be given to the satellite to escape Earth's gravitational field to the Kinetic energy required to be given so that the satellite moves in a circular orbit just above earth atmosphere is

A. 1:2 B. 1:3 C. 3:1 **D. 2:1**

47. A prism of apex angle $A = 60°$ is made from glass with refractive index $\mu = 1.5$. For a monochromatic ray the prism is used in the condition of minimum deviation. Then the angle of minimum deviation δ_m is approximately [use $\sin^{-1}(0.75) \approx 48.6$]

A. 11.4° B. 35.7° **C.** 37.2° D. 78.6°

48. The refractive index of glass with respect to air is 3/2, while that of water is 4/3. Which of the following statements correctly describes the condition for the critical angle (i_c) at the glass–water interface?

A. $0^0 \le i_c \le 30^0$ B. $30^0 \le i_c \le 45^0$ C. $45^0 \le i_c \le 60^0$ **D.** $45^0 \le i_c \le 90^0$

PART–B

MORE THAN ONE options may be correct. Marks will be awarded only if all of the correct options are bubbled.

49. Two thin coaxial lenses L_1 and L_2 are placed in contact. Their focal lengths and powers are f_1, f_2 and P_1, P_2 respectively. If the effective focal length is F, which of the following statements are correct?

A. If f_1 and f_2 are both positive, the effective focal length F equals $f_1 + f_2$.

B. The effective power of the combination is $P = P_1 + P_2$.

C. If $f_1 = -f_2$, the combination is afocal.

D. If both f_1 and f_2 are positive, the effective focal length F is always larger than the larger of f_1 and f_2.

50. A block of mass m is pushed along a rough horizontal surface by a constant horizontal force F for a distance s. The coefficient of kinetic friction between the block and the surface is μ

Which of the following statements is/are correct?

A. The work done by the frictional force is $-\mu mgs$

B. The change is kinetic energy of the block is $Fs - \mu mgs$

C. If $F = \mu mg$ the blocks move with constant velocity

D. The net work done on the block is zero only if $F = 0$

51. Two wires A and B made of the same material have the same length but different radii r_A and r_B ($r_B = 2r_A$). Both are connected in parallel across a battery of emf E with negligible internal resistance. If the total power dissipated in the combination is P, what fraction of the total power is dissipated in wire A?

A. $\frac{1}{5}P$ B. $\frac{1}{4}P$ C. $\frac{1}{3}P$ D. $\frac{1}{2}P$

52. As the temperature increases, the behaviour of electrical resistance differs for conductors and semiconductors. Which of the following statements is/are correct?

A. For a metallic conductor, R increases with T

B. For a semiconductor, R decreases with T

C. In conductors, increase in R with T is due to increased lattice vibrations.

D. The T coefficient of R for a semiconductor is negative.

53. A thin double convex lens of radii of curvature $R_1 = 20\,\text{cm}$ and $R_2 = 60\,\text{cm}$ is made-up of glass with refractive index $\mu = 1.5$. Let the focal length of the lens be f. Choose the correct option(s)

A. In air, $f = 30\,\text{cm}$.

B. The lens behaves as a concave mirror $f_M = 10\,\text{cm}$ when silvered on the R_2 surface.

C. The lens behaves as a concave lens if beyond R_2 surface is filled with a transparent liquid with $\mu = 5/3$.

D. A beam of rays incident parallel to principal axis never focuses behind the lens.

54. A battery of emf 12 V and internal resistance 1 Ω is connected in series with a resistor $R_1 = 3\Omega$. Across the terminals of R_1, a parallel branch is connected that contains two resistors $R_2 = 6\Omega$ and $R_3 = 3\Omega$ in series. Find the current supplied by the battery (in amperes).

A. $1.2A$ B. $1.5A$ **C.** $1.6A$ D. $1.8A$

55. An incompressible, non-viscous fluid of density ρ steadily flows through a horizontal pipe from cross-sectional area decreases from A_1 to A_2 ($A_1 > A_2$). The pressure and velocity of the fluid while passing through the area A_1 are P_1 and v_1, respectively. The pressure at the cross-sectional area A_2 is

A. $P_1 + \frac{1}{2}\rho\left(1 - \frac{A_2^2}{A_1^2}v_1^2\right)$ **B.** $P_1 + \frac{1}{2}\rho\left(1 - \frac{A_1^2}{A_2^2}\right)v_1^2$

C. $P_1 + \frac{1}{2}\rho\left(1 - \frac{A_1^2}{A_2^2}v_1^2\right)$ D. $P_1 + \frac{1}{2}\rho\left(1 - \frac{A_2^2}{A_1^2}\right)v_1^2$

56. A transparent right-angled triangular prism ABC, with BC as its hypotenuse, is placed in air. A ray incident on the face AB and travelling parallel to the hypotenuse emerges from the face AC grazing the surface, whereas a ray incident on the face AC and also parallel to the hypotenuse is totally internally reflected at the face AB. The range of values of the refractive index μ of the prism material is

A. $\mu > 2$ B. $\mu < \sqrt{\frac{3}{2}}$ C. $\sqrt{2} < \mu < \sqrt{3}$

D. $\sqrt{\frac{3}{2}} < \mu < \sqrt{2}$

57. A ball of mass m is falling from the top of a multi story building of height h. Which of the following statements are correct about the motion of the ball? (Neglect the air resistance)

A. v increases linearly with t

B. s vs v graph is parabolic

C. mgh equals total K.E. before hitting the ground

D. K.E. linearly increases with t

58. Two small stars of masses M_1 and M_2 initially far apart are at rest. The stars move towards each other under gravitational attraction. The velocity of approach, when the two stars are a distance d apart, is equal to

A. $\sqrt{\frac{GM_1}{d}} + \sqrt{\frac{GM_2}{d}}$ **B.** $\sqrt{\frac{G(M_1+M_2)}{d}}$

C. $\sqrt{\frac{2GM_1}{d}} + \sqrt{\frac{2GM_2}{d}}$ D. $\sqrt{\frac{2G}{\left(\frac{1}{M_1}+\frac{1}{M_2}\right)d}}$

59. A long straight wire carrying a steady current I lies along the z-axis. A square loop of side a, carrying a current I', lies in the xy-plane such that its nearest side is at a distance r from the wire ($a << r$).

Consider only the magnetic interaction between the wire and the loop.

Which of the following statements are correct?

A. The magnitude of the magnetic force on the nearer side of the loop is greater than that on the farther side..

B. If the currents I and I' flow in the same sense (as seen from $+z$), the net force on the loop is towards the wire (i.e. attractive).

C. The net torque on the loop about the z-axis (the axis of the straight wire) is zero.

D. The loop experiences a net force perpendicular to the xy-plane (i.e. a net force along z).

60. A thin symmetric bi-convex glass lens of refractive index μ_l is placed in a surrounding medium of refractive index μ_m. Which of the following statements are necessarily true (for arbitrary curvatures, assuming thin-lens approximation)?

A. If $\mu_l \to \mu_m$, $f \to \infty$

B. If $\mu_m > \mu_l$, it becomes diverging

C. Immersing the lens in a medium with μ decreases $|f|$.

D. If $\mu_e l = 1.5$, $\mu_m = 1.2$, the f increases.

***** $\varepsilon\eta\delta$ *****